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CONCRETE BLOCK GARAGES

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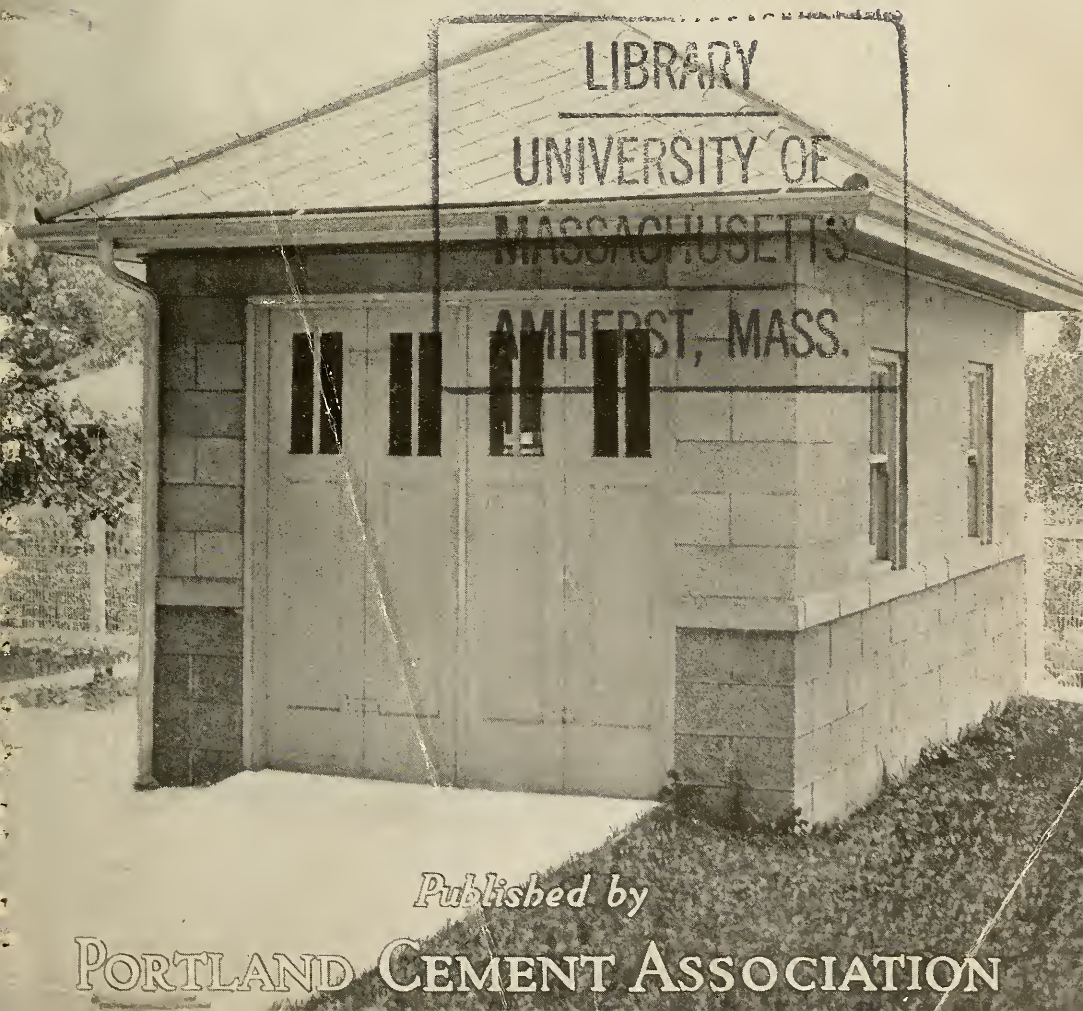


Published by

PORTLAND CEMENT ASSOCIATION

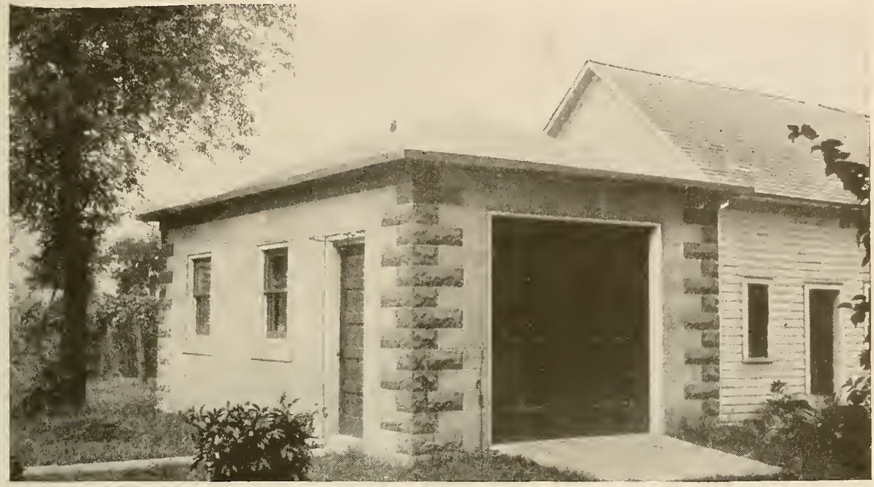
Concrete Block Garages

THE amount of money invested in the average automobile or motor truck justifies a substantial garage that will afford the required protection against weather, theft, and fire.

Concrete block enables the construction of a garage with architectural effect harmonizing well with almost any surroundings

WHY THE PRIVATE GARAGE IS DESIRABLE

Many automobile owners believe that a private garage proves more satisfactory than renting space in public storage. The home garage can be located near the owner's residence, while rented space is seldom within convenient distance. With a garage on the home grounds he has his car where the most use can be made of spare time to keep the machine clean and in good running order. He has a place to keep oil, grease and other car supplies and can therefore purchase them at quantity prices when these offer attractive savings. Not only is it handier to have the car near the house for use in bad weather and in emergencies, but there will be less danger from fire, tampering and pilfering, as the owner is usually able to keep closer watch of garage and car.



Through fire-safe construction afforded by concrete block, the car housed in this garage is given much needed fire protection when the garage is near combustible structures

FIREPROOF CONSTRUCTION A NECESSITY

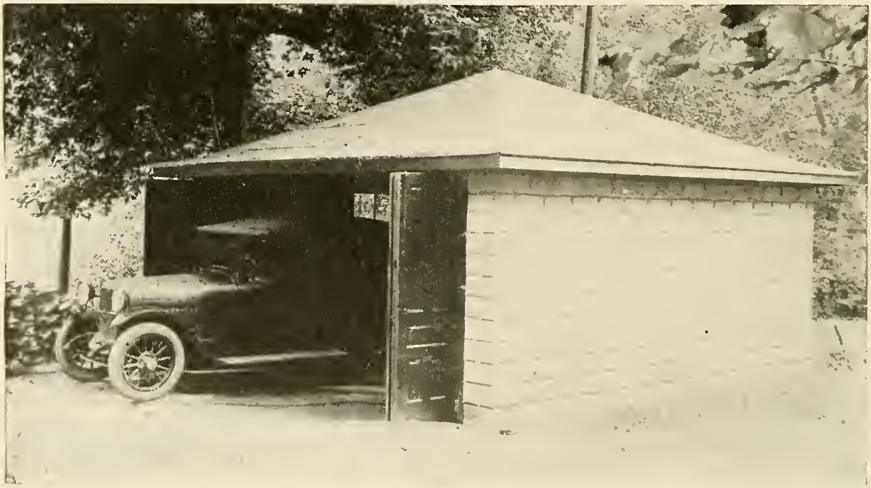
In addition to the fire hazards common to other buildings, garages have a peculiar hazard of their own due to the presence of oils and gasoline necessary to car operation. Too often garages are built of short-lived, combustible material—built to increase the fire risk rather

The two-car garage has become very popular. If the owner needs only one side, the other can be rented out at a good profit than to reduce it. Fire may originate in a garage of non-burning construction but is not likely to make headway and is almost certain to be confined where it starts, so nearby structures are safeguarded. A fire-resistant garage also protects its contents from fire which may originate in adjacent buildings. Fire risk is one of the greatest with which the car owner has to contend. This can be reduced to a minimum with fireproof construction. Concrete, because of its fireproofness, makes the ideal building material for a garage.

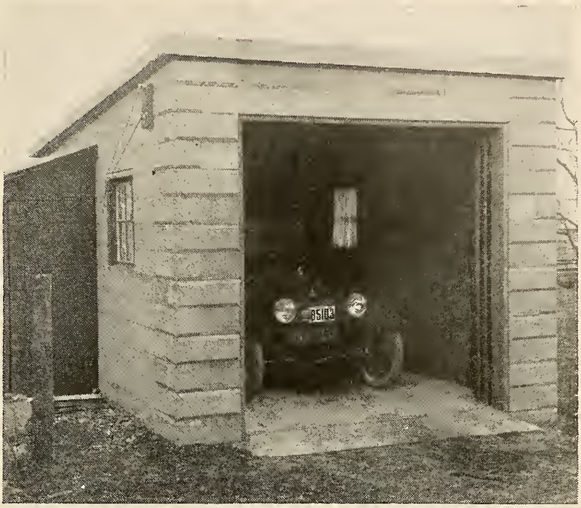
In many cities building regulations require that buildings of inflammable construction be built five or ten feet away from the lot line but allow fireproof buildings to be built on the lot line. On narrow city lots fireproof concrete block garages have a decided advantage over inflammable garages in saving space. The five foot strip of land between lot line and an inflammable garage is practically useless. It is too narrow to cultivate and is shaded by the garage. With fireproof concrete block construction it is possible to erect two garages side by side with a fireproof party wall on the lot line, resulting in a saving of space for both owners.

SEPARATE STRUCTURE ESSENTIAL

A building used for no other purpose than to house the car generally proves most economical and efficient. In some rural districts automobile and truck owners make a practice of keeping their cars in



A simple inexpensive two-car garage constructed of concrete block with beveled edges

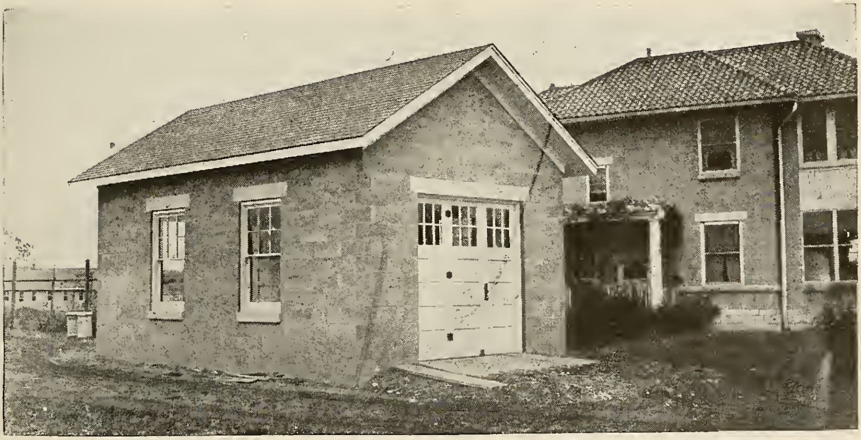


Concrete block garage with monolithic concrete roof. Simple ornament is given by the manner in which block are laid at corners

outbuildings. Running the automobile into the barn where live stock is kept, or in a shed adjoining the barn, is not good practice. Fumes from stable refuse soon dull the gloss and luster of the varnish and tarnish the polished metal trim. Dust and moisture, which are always present around a barn, are also injurious to varnished surfaces and increase the labor of keeping the car clean. Storing the automobile in a building with live stock, grain or machinery increases the fire risk all around.

CONCRETE BLOCK GARAGES POPULAR

Thousands of concrete block garages in successful use and large numbers now being erected, furnish the best proof of their fitness and

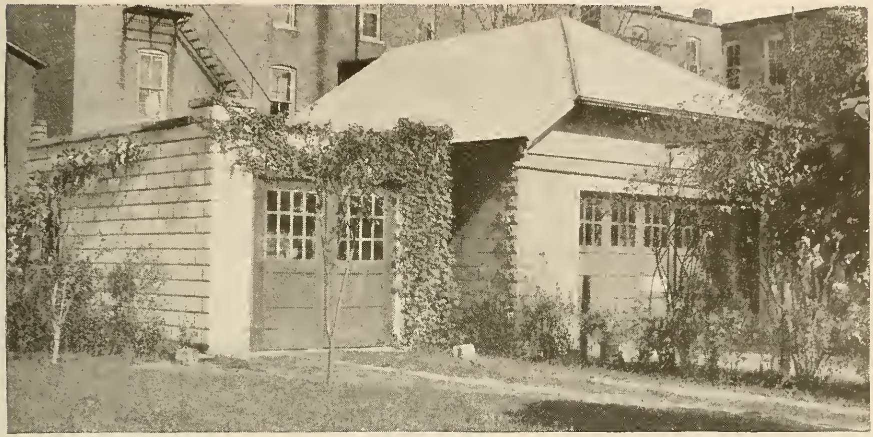


The employment of special sill and lintel block adds to the general attractiveness of this smooth-faced block garage ability to meet even the most exacting requirements. Concrete blocks are suitable for all classes of garages from the smallest one-car building to the types with separate rooms for several cars, such as are usually built for the accommodation of car owners living in apartment houses. Concrete block proves its adaptability both in the simple and inexpensive, and in the more elaborate and pretentious garages.

The owner of this simple little concrete block garage enjoys full measure of satisfaction from the protection which it affords his car

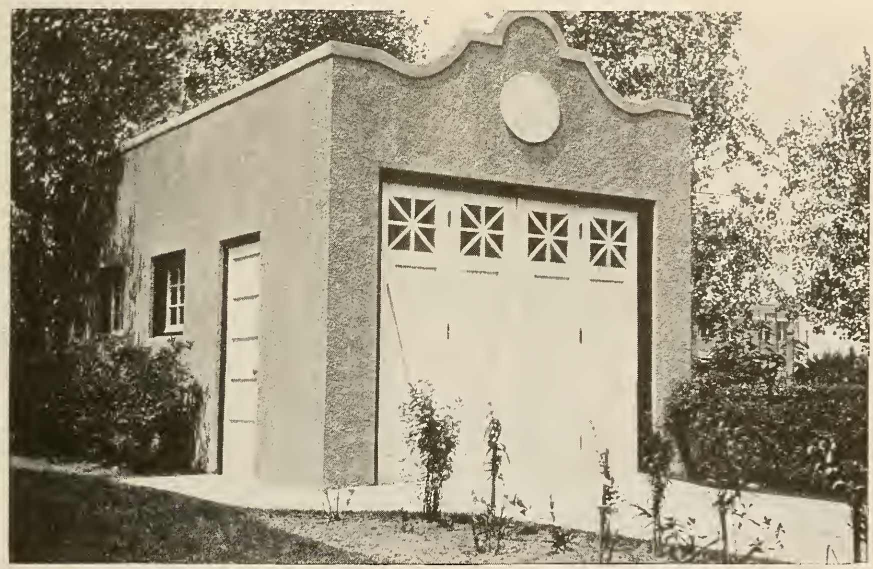
As the garage is generally located near the house, it should be an attractive structure that will add to the beauty of the place. Buildings with concrete surfaces harmonize well with other structures and with natural surroundings, whether in town or country, and provide an atmosphere of stability which makes them doubly attractive.

Concrete block permit a wide variety of architectural treatment. Almost any kind of surface can be secured. Most cement products manufacturers are prepared to supply several types of face block. Some block are made with a special facing mixture of crushed granite, marble chips or similar material. Such blocks compare in beauty and



With cement asbestos shingles or other noncombustible roof covering, the concrete block garage becomes a thoroughly fire-safe structure

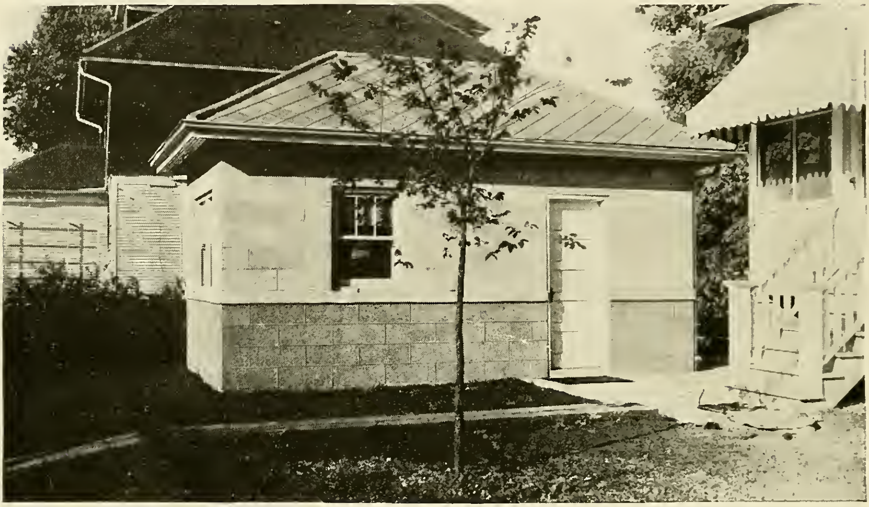
artistic appearance with the finest grades of cut stone. Where stucco finish is desired, block with plain surfaces are used and covered with pebble-dash or other stucco coat. Concrete block provide a most satisfactory backing for stucco, which can be applied quickly and easily.



No other building material forms a better ground for stucco than does concrete block as illustrated by this attractive, stuccoed garage

PERMANENCE

The concrete block garage is so substantial as to be unaffected by the elements. It will neither rot nor burn. Maximum protection is secured when the automobile or motor truck is housed in a concrete block garage.



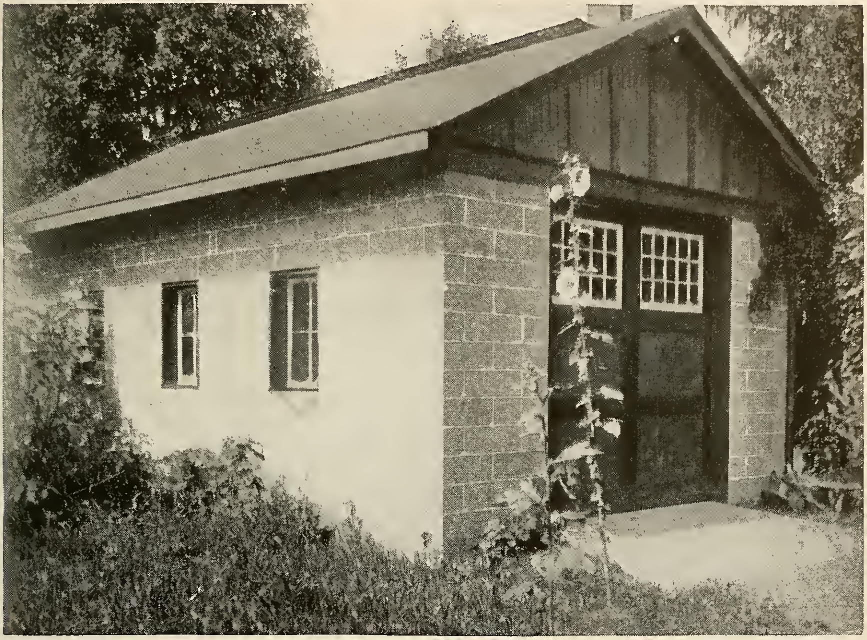
The block of which this garage is built have received surface treatment to expose the selected aggregate used in the concrete. It is convenient in bad weather, or in case of emergencies, to have the car housed near the residence

REASONABLE IN COST

What a garage really costs should be determined by the number of years of service it will render. A good way to arrive at the real cost is to divide the first cost by the life of the building in years. Because a concrete block garage is practically permanent, the cost per year will be very low. There will be no bills for painting or other maintenance and repair except for wooden window frames, doors and trim. Even these may be of metal, thus almost eliminating upkeep. In the meantime, the car owner enjoys a sense of security in the knowledge that his machine has the maximum amount of protection.

CONCRETE BLOCK A DEPENDABLE BUILDING MATERIAL

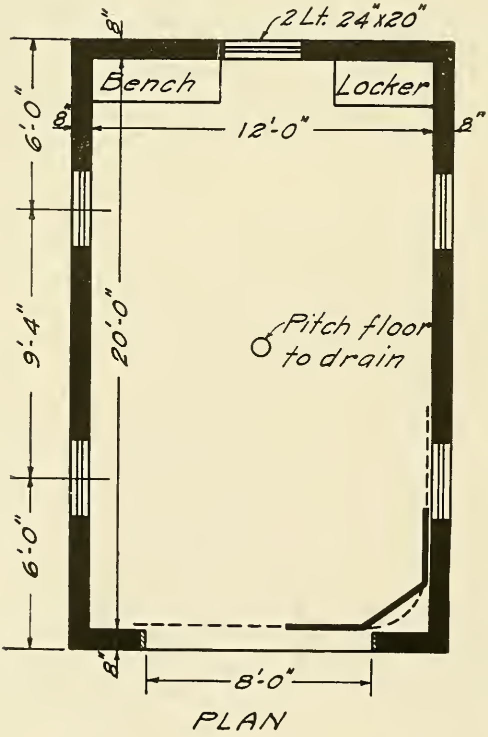
The extensive and increasing use of concrete block for all classes of structures indicates that the faith which architects, builders and contractors have in these building units is well justified. Concrete blocks



The garage being near the house must look well. That is why particular people build of concrete block

A concrete approach and walk is a desirable convenience and adds to the finished appearance of the garage. This structure shows how pleasing an effect can be obtained by the use of plain concrete block

For long life, low cost of upkeep and dependable service, a concrete block garage is unexcelled

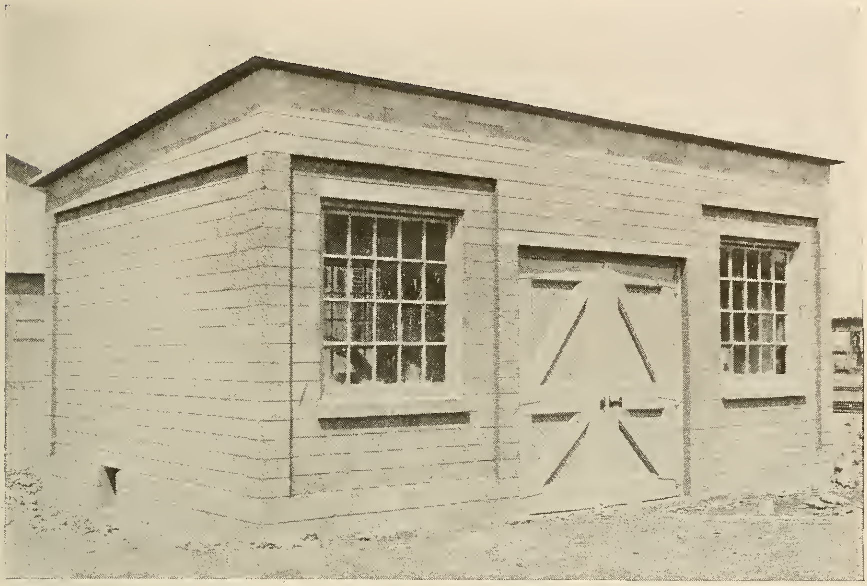


Floor plan of simple one-car concrete block garage

are generally made by local manufacturers who must depend upon the quality of their products to build up and increase their business. Local block manufacturers deserve your patronage.

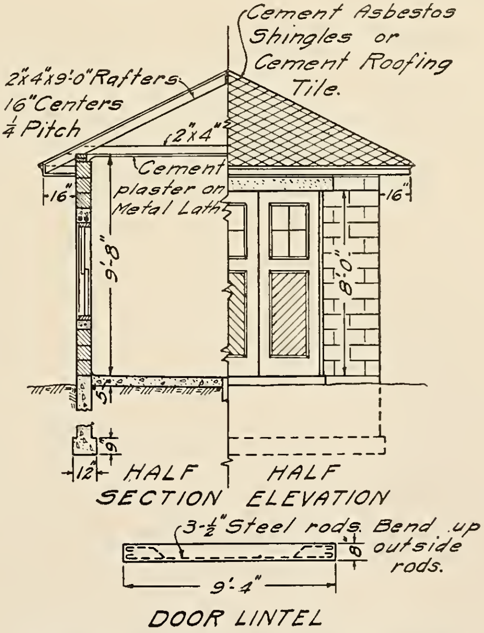
BUILD THE GARAGE LARGE ENOUGH

Many car owners make the mistake of building the garage too small, then when they dispose of their old car and secure a larger one, they find the space inadequate. Either an addition must be built to the old garage or an entirely new building erected at considerable expense.



This concrete block garage, with its paneled wall surface, shows one of the many ways in which individuality can be simply expressed with concrete block

For single car garages, an inside width of 12 feet has been found satisfactory and for a two-car garage 20 or 22 feet. A length of less than 20 feet is seldom advisable. For larger cars, 22 feet to 24 feet is better. These dimensions will allow plenty of working space around the car and provide room for a small work bench, closets and shelves for car accessories across one end.


Cement Asbestos Shingles or Cement Roofing Tile.
2"x4"x9'-0" Rafters 16" Centers 1/4 Pitch
2"x4"
Cement plaster on Metal Lath
16"
16"
9'-8"
8'-0"
5"
9"
12"
HALF SECTION
HALF ELEVATION
3-1/2" Steel rods. Bend up outside rods.
8"
9'-4"
DOOR LINTEL

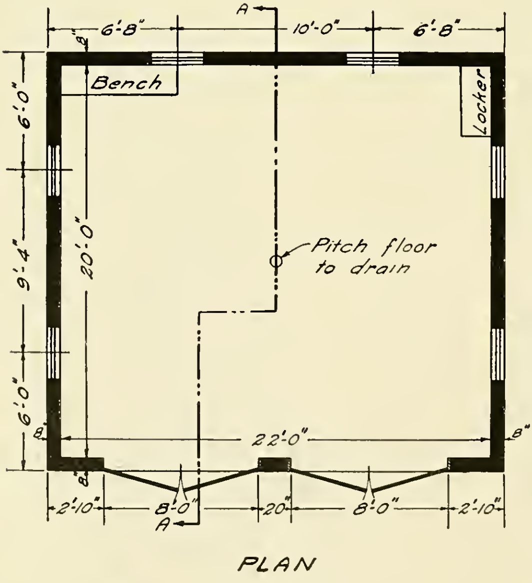
Half section and half elevation of one-car concrete block garage corresponding to floor plan shown on opposite page

The following table gives length of several kinds of cars when equipped with front bumper and with the top down:

Make of Car	Wheelbase	Total Length with Front Bumper and with Top Down
Ford	100 inches	12 feet 9 inches
Overland	100 inches	13 feet 6 inches
Maxwell	109 inches	13 feet 10 inches
Essex	108 inches	13 feet 4 inches
Hupmobile	112 inches	14 feet 0 inches
Dodge	114 inches	14 feet 6 inches
Reo 7 passenger touring	120 inches	14 feet 2 inches
Studebaker 7 passenger touring	126 inches	15 feet 6 inches
Buick, Six	124 inches	15 feet 6 inches
Hudson	126 inches	16 feet 2 inches
Paige	131 inches	16 feet 6 inches
Packard, Twin six	136 inches	16 feet 10 inches
Cadillac	132 inches	16 feet 6 inches
Pierce Arrow 7 passenger touring	138 inches	17 feet 4 inches

TWO-CAR GARAGES GROWING IN FAVOR

The two-car garage is becoming increasingly popular even among men who only own one car. The extra space can usually be rented to neighbors at a profit, or comes in handy as a storage place for extra body or top. There is also the possibility that two cars will be owned at some future time. In sections where motor trucks are coming into general use the advisability of building a garage large enough for both car and truck deserves consideration. Since the dimensions of the truck are usually greater than those of the car, this fact must be taken into consideration at the outset

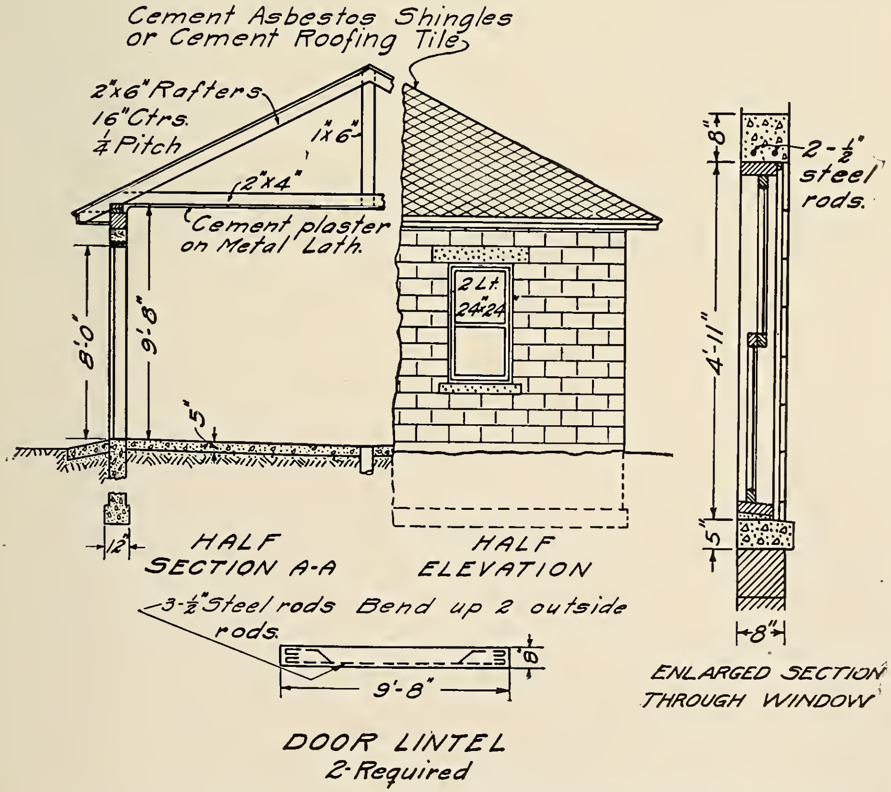


Plan for two-car concrete block garage

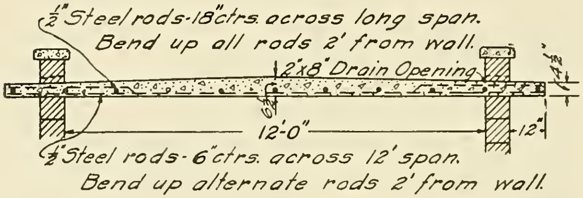
FIRE-RESISTANT ROOF ESSENTIAL

Complete fire protection demands that the garage roof be of reinforced concrete. The sketch on page 14 shows one method of building a roof of this type. However, reasonably fire-safe construction can be secured by a frame

Winter or summer, spring or fall, a concrete block garage resists all kinds of weather and gives the car it houses a full measure of protection



Half section and half elevation of two-car concrete block garage shown on opposite page, also some details of reinforcement of window openings and door lintel roof covered with cement asbestos shingles or cement roofing tile and cement plastered ceiling inside on metal lath.


½" Steel rods-18" ctrs. across long span.
Bend up all rods 2' from wall.
2"x8" Drain Opening
4½"
6½"
12'-0"
12"
½" Steel rods-6" ctrs. across 12' span.
Bend up alternate rods 2' from wall.

The one-car block garage shown in the sketch on page 11 can be made fireproof throughout by a reinforced monolithic concrete roof, details of which are illustrated above

Cement roofing tile improve the appearance and fireproofness of this two-car garage. The black mortar joints and door trimming also add to its attractiveness and contrast well with the block construction

EVERY GARAGE SHOULD HAVE A CONCRETE FLOOR

A concrete floor is worth many times its cost. It is easy to build and presents a smooth even surface that can be kept clean. It is a good plan to give the floor a slope of about one inch in eight feet toward a drain, usually located near the center. A concrete approach built on an easy slope is also desirable so that the car can be run in or out without jolting. Without this approach, ruts are likely to develop in front of the doorway. The concrete approach adds materially to the finished appearance of the garage and its surroundings.

LARGE, EASILY OPERATED DOORS

The car door openings should not be less than 8 feet wide and at least 8 feet high. Many satisfactory hinges and door hangers have been perfected and can usually be obtained from local hardware dealers.

PLENTY OF LIGHT

Garage interior should be well lighted so that repairs may be made without artificial light. Windows should be large and well distributed around the building and placed low in the wall, to admit the light near the floor rather than toward the ceiling. Electric light furnishes the safest kind of artificial illumination.

A commercial garage of concrete block is economical in cost, insurance, and upkeep. Its substantial appearance and firesafeness attract trade

CONCRETE BLOCK GARAGE EASY TO HEAT IN WINTER

Because of the air space in concrete block walls, structures made of concrete block are easy to heat. This air space insulates the interior against sudden changes in outside temperature and in the same way prevents loss of such heat as may be supplied to warm the interior. Heating should preferably be done by extending hot water or steam pipes from the residence heating plant.

BUILD OF CONCRETE BLOCK

Concrete block meet every requirement of the modern garage at a reasonable cost. Pleasing in appearance, durable in construction and affording maximum protection against fire and weather, the Concrete Block Garage provides the very best housing for automobiles and trucks obtainable at any price. See your local block contractor and get his figures.

Your trim little Concrete Block Garage needs the finishing touch of a Concrete Driveway like this one

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helpful to you when you build that
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Massachusetts Agricultural College,
AMHERST, MASS.

Concrete Feeding Floors Barnyard Pavements and Concrete Walks

Published by
Portland Cement Association
111 West Washington Street
Chicago

SEPTEMBER, 1916

"Concrete for Permanence"

Money saved is money made.

Feed wasted in the mud is money lost.

Concrete feeding floors and barnyard pavements are money makers.

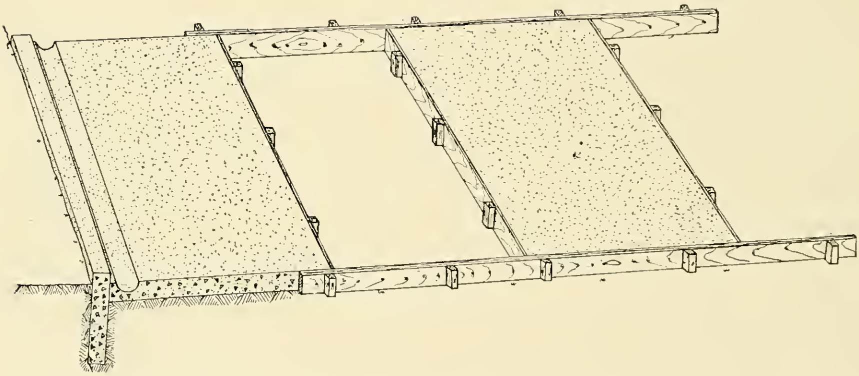
CONCRETE FEEDING FLOORS, BARNYARD PAVEMENTS AND CONCRETE WALKS

OF all the farm appointments which can be secured through the medium of concrete, none is easier to build nor more certain to give good returns on the money and labor expended than a concrete feeding floor. Those who have had much experience in stock feeding, both in the open pasture lot and on a smooth concrete floor where no grain can be lost, have proved conclusively that such a floor can be made to pay for itself in not more than two years and often within a year. In many instances where careful records have been kept, cattle feeders who specialize on fattening stock exclusively for market have obtained even quicker return of the investment involved.

This is the usual and far too common knee-deep feeding lot. Not only is it insanitary, but it increases the labor of feeding, the waste of feed, and the loss of valuable fertilizer.

Advantages of concrete floors are numerous. There is not only greater gain in weight of cattle and hogs fed on a floor where grain cannot be lost and where accumulation of filth can easily be prevented, but there is the sanitation resulting from the concrete surface, which cannot absorb filth and can be cleaned readily by scrubbing with water or applying some germicidal solution. If necessary, the floor can be sprayed with gasoline and the fuel set on fire, thus making sanitation doubly certain. If feeding is done on a pavement, there is no wading through mud, neither for the farmer nor the animals being fed.

But these are not the only advantages. Manure that can be saved by feeding on a paved surface represents no small item, as has been proved by many experiments. Tests made at the Ohio Experiment Station to determine the relative value of manure removed from the concrete floor as compared with that gathered from the unpaved feed lot, proved not only that there was more manure saved from the concrete floor but a greater percentage of the phosphorus, potash and nitrogen contained in the feed consumed was recovered in the manure. This, because when properly planned the concrete feeding floor is built so that its surface drains into a concrete gutter—a part of the floor—which in turn is connected to a tile line leading to a sump or manure pit cistern where all the liquid manure is saved. This means more cash for the business farmer who is endeavoring to conserve and build up soil fertility by preventing waste of every fertilizing element.



Form construction for concrete feeding floors and barnyard pavements is of the simplest type Two by fours securely staked in place are all that is needed. This sketch shows a portion of what will be one strip of such a floor, and illustrates how the curb apron and gutter should be constructed.

Feeding stock on concrete floors reduces the labor of feeding considerably. Every one knows that at some seasons, any unpaved feed lot will become a mudhole. Any grain or fodder thrown out for cattle either becomes tramped into the mud, or so covered with dirt and filth that the animals will not eat it, so a large portion is wasted. Only corn that gets inside of a hog will make pork.

To meet all desirable requirements, a feeding floor must have a surface that will be smooth, easily kept clean and will not absorb filth or wastes that may be dropped upon it—a surface that can easily be disinfected, and of material that is permanent. All these possibilities are characteristic of concrete. If concrete floors are properly constructed, they are not only moderate in first cost but practically everlasting. Rats and mice find convenient breeding places beneath wood floors and thrive on grain that the stock waste. The wood floor cannot be kept sanitary;

and from the very fact that it usually is built in contact with the soil, soon requires replacement as a result of rapid decay.

What has been said so far of concrete feeding floors applies equally to barnyard pavements, since the paved barnyard is usually only a larger paved area than the concrete feeding floor, and the same advantages and profits result from the concrete-paved barnyard as are identified with the concrete feeding floor.

Concrete feeding floors and barnyard pavements are not difficult to build. The home worker who has had a moderate amount of experience in concrete work can build them easily; and the man who has never had any such experience can easily acquire the necessary skill if he is careful to follow directions.

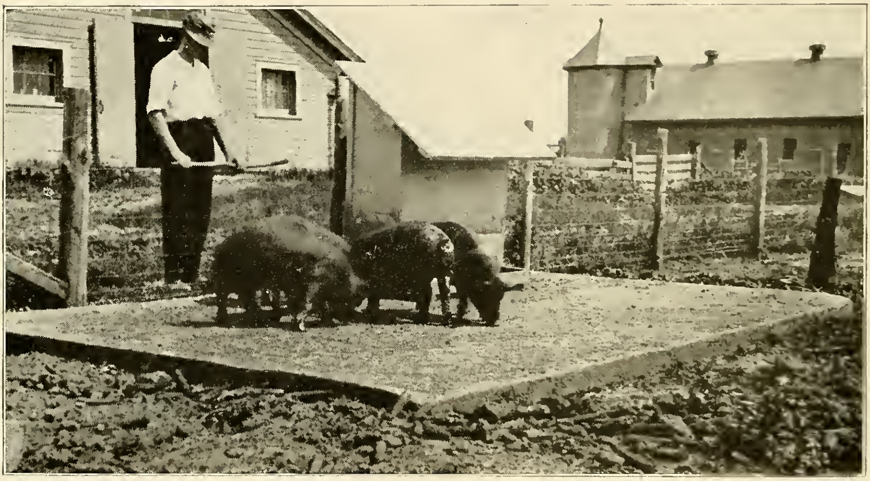
Concrete feeding floors may be compared to a series of concrete sidewalks laid side by side; that is, if you were to take the ordinary well-built concrete sidewalk and move the slabs around so that they lay in rows, four, five or six slabs long and two, three or more wide, you would have the concrete feeding floor or concrete barnyard pavement.

Although the feeding floor may be rectangular or any other shape, most farmers prefer a square floor. Fifty hogs require a paved area of at least 24 by 35 feet. This allows 18 square feet per hog, which is about right to prevent the animals from disturbing one another while feeding. As a rule, it is not economical nor desirable to build a floor having an area less than 200 square feet.

There are two types of construction that may be employed for concrete feeding floors and barnyard pavements—one, and two-course. In one-course construction a relatively rich concrete, such as a 1:2:3 or 1:2:4 mixture, is used throughout and placed at one operation to the required thickness. In two-course construction a leaner concrete, such as a 1:2½:5 mixture, is used for a 4-inch base, with a 1-inch top or wearing course of richer (1:2) proportion. The greater ease with which one-course floors can be constructed makes this type preferable for paving feed lots and barnyards.

Concrete feeding floors for hogs are often made 4 inches thick. This is sufficient where there is no danger from freezing and heaving, but 5 inches thick is better. If the floor is separate from the barnyard pavement, it should have a curb and apron on all sides, extending a foot or more below the surface of the ground and two or three inches above the pavement. This will prevent hogs from rooting underneath, and from shoving grain off the floor. Where the ground is firm and well drained, concrete may be laid directly upon the soil without any special foundation or subbase after the natural soil has been properly leveled and uniformly compacted. All vegetation should be removed from the site and any soft spots be filled with gravel or clean cinders free from ashes, wet down and well compacted. A location should be chosen for the floor that is slightly higher than the immediate surroundings so that drainage will be good from beneath the pavement. But if the site is on soft soil or where water is likely to be retained for a time during certain seasons, an 8-inch subbase of well tamped or rolled cinders or gravel is advisable, and drain tile should be so laid as to drain water from the subbase. If this is not done water is likely to be retained beneath the pavement, and freezing and the subsequent expansion may cause the slabs to heave. Even though none of the slabs might be broken, the floor would probably have an uneven surface due to unequal settlement after the heaving has subsided.

The feeding floor should have a slope of ¼ inch to the foot toward a gutter at one side. This gutter will receive the liquid wastes dropped on the floor as well as water used for washing it, and this gutter in turn should have a slight slope and be connected to a tight concrete tile drain leading to a cistern or sump where the liquids may be collected and preserved for the fertilizing value they possess.



On the concrete feeding floor every grain of feed gets where it belongs—inside the animals for which it is intended. This floor would have been better if a curb had been built around it so that grain could not be pushed off the floor while the hogs are feeding and to prevent them from rooting underneath.

Slabs of a concrete feeding floor may well be limited to not greater than 6 feet square. Forms should be of 2-inch lumber 4 or 5 inches wide, depending on the thickness of the pavement. The top of forms should be set to such a grade that a slope of ¼ inch to the foot will be secured for proper drainage of the pavement surface. Not all of the area which it is intended to pave should be laid out with forms at one time; instead forms for one row of slabs only need be provided for, just as though a sidewalk were to be constructed. Then after having blocked off this strip into 6-foot squares with partition strips, concrete should be placed for alternate slabs and after these have hardened sufficiently to be self-sustaining, the cross pieces can be removed and the intermediate slabs concreted, this operation being repeated alongside of the first and subsequent strips (which will then serve as a form for one side) as many times as necessary to secure the desired width of floor.

Concrete for feeding floors and barnyard pavements where the work is one-course construction, should be a 1:2:3 mixture although if care is used to select well graded sand and pebbles, a 1:2:4 mixture will accomplish the purpose; but for the greatest degree of sanitation, the surface must be non-absorbent and this means a watertight concrete which the home worker will be more certain to secure by using a 1:2:3 than a 1:2:4 mixture. Sand should range from fine to ¼ inch with the coarser particles predominating, while pebbles should range from ¼ to 1 or 1¼ inches. Both sand and pebbles should be clean and free from clay or other foreign matter. (A 1:2:3 mixture means 1 sack of Portland cement, to 2 cubic feet of sand and 3 cubic feet of pebbles or broken stone.)

Many persons have the impression that when definite proportions of sand and pebbles are specified the same results can be secured by substituting for them an equal bulk of bank-run material, that is, sand and pebbles as found combined in the ordinary gravel pit. This is incorrect since the volume of air spaces (voids) in bank-run material requires more cement for filling than would be used with a properly proportioned mixture of cement, sand and pebbles. Bank-run gravel should never be used for concrete work until screened, so that the fine and coarse materials (sand and pebbles) can be correctly reproportioned.

In mixing the correctly proportioned materials for one-course construction, enough water should be added to produce a concrete of quaky or jelly-like consistency, so that it can be quickly spread about in the forms and easily leveled with a strikeboard resting upon the top edge of forms. This should be passed across the surface with a saw-like motion, thus leveling the concrete and at the same time assisting to compact it.

When mixing concrete it is very important that just the right amount of water be used and that mixing is sufficiently thorough to make certain that every particle of cement is wet and the materials thoroughly and intimately combined. Concrete hardens best when kept moist. Unless a sufficient amount of water is used when making concrete mixtures, there will not be enough moisture present to permit the cement to undergo the chemical changes necessary to fully develop its binding qualities. On the other hand, one must be careful not to use too much water as this will cause the sand-cement mortar to separate from the pebbles or broken stone. If mixed to the right consistency, the surface can usually be given its final finish within not to exceed half an hour after placing. Finishing should be done with a wood float, not with a steel trowel. The former gives an even, yet slightly gritty surface that forms a sure foothold for the animals, while the steel trowel not only tends to produce a slippery surface but there is a tendency when finishing with a steel trowel to overtrowel, thus bringing an excess of cement and fine sand to the surface which considerably impairs the wearing quality of the floor.

After the concrete has been finished with the wood float and the surface has become sufficiently firm to resist pressure of one's thumb, there should be applied a protective covering of moist sand or earth so as to prevent the concrete from drying out too rapidly. Regardless of how well the materials may have been proportioned, mixed and placed, the final results will not be satisfactory unless this precaution of protecting the floor properly while hardening is observed. Hot sun and dry winds will rob the concrete of moisture and thus prevent proper hardening, so the protective covering must be applied just as soon as possible to do so without marring the surface and, furthermore, should be kept wet by frequent sprinkling for a week or ten days. After this the concrete floor may be put to its intended use although wagons should not be driven over it until the concrete is at least a month old.

Concrete pavement in the barnyard converts it into a sanitary exercising lot for the stock. Nature largely attends to cleaning the surface with rain and sunshine.

This brings up the point of heavy teaming over paved barnyards. If there is to be much heavy hauling across a barnyard pavement, it would be well to increase the thickness to at least 6 inches.

Many farmers are paving their entire barnyard with concrete, thus making of the area that once was a knee-deep mudhole, a sanitary feeding and exercising lot for the stock.

CONCRETE WALKS

Because of the resemblance between concrete feeding floors and barnyard pavements and concrete walks, no detailed description of constructing a concrete walk is necessary. As in the construction of a concrete feeding floor, consideration must be given to the character of the soil upon which the walk is to be laid and sometimes a subbase or special foundation is necessary. So far as possible, a concrete walk should be built where drainage will be good, but if this cannot be done, a subbase must be built by compacting clean gravel or cinders, then side drains should be laid to lead water away from this subbase.

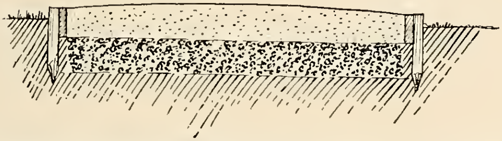
Where there is not much heaving of soil because of the fact that it is loose and well drained, slabs for farm walks need not be thicker than

4 inches, but 5 inches is better. In no case should individual slabs exceed 6 feet in any one dimension.

Forms in which to place the concrete must be provided, the course of the walk being first marked with strings stretched from stakes. Then the sod is removed, loose soil dug out and the foundation compacted. Usually 2 by 4's well staked in position will serve as forms. One-inch lumber is sometimes used but, unless well staked, the placing of concrete will often make such light forms bulge out of line, thus affecting the appearance of the finished walk. If the walk is to be 5 inches thick, then 2 by 5's should be used for forms so that the concrete will be placed to the required thickness.

For most if not all farm walks, one-course construction will be found best. This can be floated readily with a wood hand float to the desired surface finish, if pebbles no larger than ¾ or 1 inch are used when proportioning the concrete mixture.

The same consistency of concrete should be used for walks as for feeding floors. If it is desired to have the walk curved at some point, ½-inch siding or weather boarding is easy to stake to moderate curves, and where sharper ones are necessary, strips of sheet metal of the desired width can be used.



A section of a concrete walk which has been struck off with a template cut out on the lower face so as to give the surface of the walk a slight crown.

If two-course construction is used, a leaner mixture may be employed for the base, such as a 1:2½:5. This should be mixed with less water than would be used for a quaky consistency, then leveled off one inch below the top of forms. The right consistency will be recognized when water flushes to the surface under moderate tamping. Immediately after placing the base, a 1:2 mixture for the wearing course, one inch thick, should be applied, this consisting of cement and sand only, in which 1 sack of Portland cement is used to 2 cubic feet of well-graded, clean, coarse sand, in which the larger particles predominate and measure not more than ¼ inch in greatest dimension. This top course should be mixed to a consistency so that the mortar will have to be scraped from the wheelbarrows or buckets when dumping into the forms, and it should be quickly leveled with a strikeboard and finished with a wood float.

In finishing walks, quick drainage of the surface may be provided for if the template or strikeboard used to strike off the surface is cut out on the lower edge, so as to produce a crown to the finished walk; but the usual practice is to set the forms so that the surface of the walk will slope to one side at the rate of ¼ inch per foot. Either method of securing drainage of the surface will be found effective. Probably the setting of forms so that the slope is toward one side will be found easier in most instances.

Only a few simple tools are required for feeding floor, barnyard pavement and walk construction, although for a neat job on walks, two tools are required which are not necessary for ordinary feeding floor and barnyard pavement work, namely, a groover and an edger. Both can be purchased from almost any hardware store. The former is intended to finish the edges of adjoining slabs neatly, while the latter is to give a rounded edge to the sides of the walk.

Concrete walks, like feeding floors and pavements, must be properly protected while the concrete is hardening. Side forms should be left in place until the concrete has hardened sufficiently to permit removing the protective covering. This will be in a week or ten days.

Tennis Courts of Concrete
Concrete Septic Tanks
Concrete Fence Posts
Small Concrete Garages
Farmer's Handbook on Concrete Construction
Concrete Facts About Concrete Roads
Facts Everyone Should Know About Concrete Roads
Proportioning Concrete Mixtures and Mixing and Placing Concrete
Concrete Foundations
Concrete Tanks, Troughs, Hog Wallows, Manure Pits and Cisterns

Are publications which may interest you. If you would like any of these booklets, write the Portland Cement Association, 111 West Washington Street, Chicago

Concrete for Sanitation

Sanitary improvements pay
The sanitary, concrete feeding
floor—the dining table of the
hog-feeding lot—
is a profitable investment

If you want to know of other uses of concrete, write the Portland Cement Association, 111 West Washington Street, Chicago

"Concrete for Permanence"

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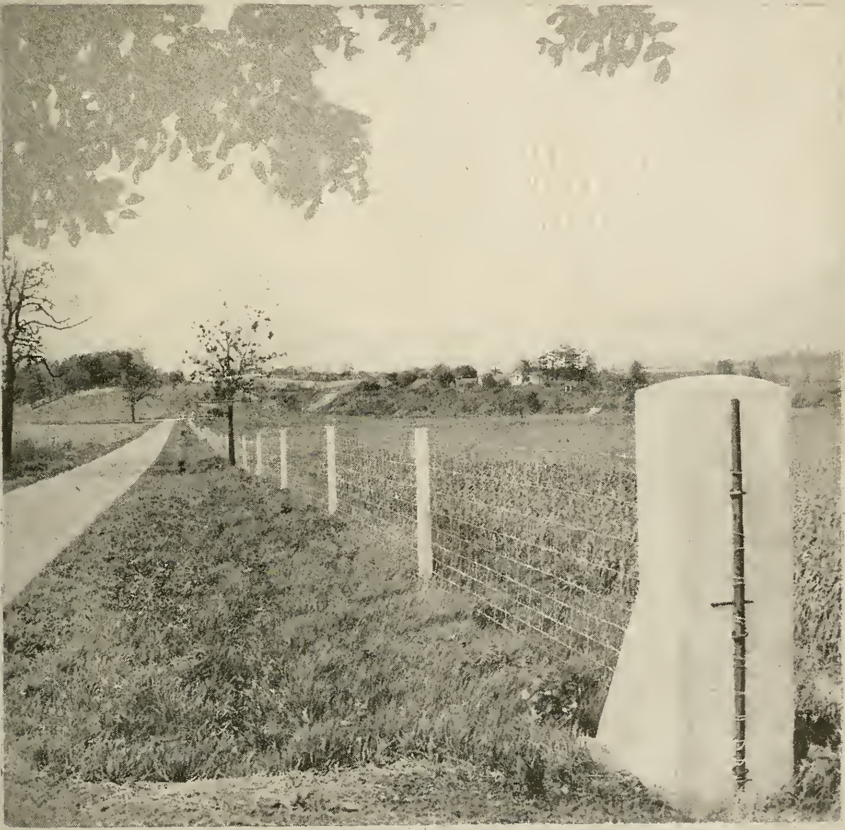
CONCRETE FENCE POSTS



Published by
PORTLAND CEMENT ASSOCIATION

CONCRETE FENCE POSTS

BECAUSE concrete has shown its suitability for many other construction purposes, it is not surprising that concrete fence posts have become popular, especially as concrete will not rot, burn, nor be affected by the wood-boring insects which are in part responsible for the short life of even the best wood posts. Furthermore, timber suitable for fence posts has become so scarce in many sections of the country that the concrete post can, in many localities, compete in first cost with the best cedar posts.

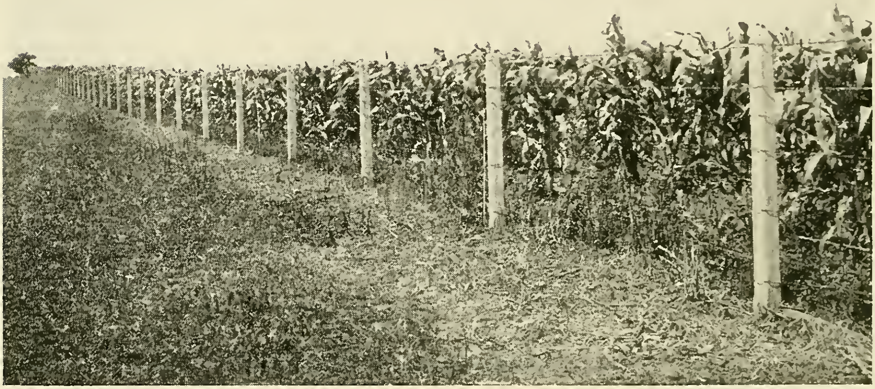


Figure 1. No annual straightening up and no replacements needed with concrete posts. Farm labor is conserved for the production of crops.

Every one who has had any considerable fencing to do, such as is necessary on the average farm, knows what an amount of time must be spent every spring in straightening up fences and putting them in first-class condition for a season's service. This work must be performed annually; and presuming that an entire fence line constructed with wood posts is built new this year, it will only be a question of four or five years when many of the posts will need renewing because of rot or fire, and probably by the end of eight years practically all will have been replaced. Therefore, the average life of a fence constructed with wood posts cannot safely be figured as greater than eight or nine years.

Concrete posts are not by any means an experiment. They have been in use long enough to prove that if well made, their life may be almost indefinite. If they fail and require replacement, it is because they were not properly made or were subjected to some sudden blow or strain which could not be foreseen and prevented. Concrete fence posts therefore make a strong appeal, because a fence once built with properly made concrete posts need be given no maintenance unless the fencing wires or fabric rust out or break, and this of course cannot be attributed to the concrete post.

Concrete Posts Are Fireproof

Wherever a fence is placed it is necessary that some land, even though it be a narrow strip, shall be kept out of cultivation. The only way successfully to prevent the weeds which grow on such a strip from flourishing all over the farm is to burn the strip over and kill the weed seeds, at the same time, of course, consuming all the rubbish of vegetation. With wood posts, burning cannot be done without considerable injury to, if not destruction of, the posts. The concrete post is proof against fire, so fence strips can easily be kept from becoming unsightly.

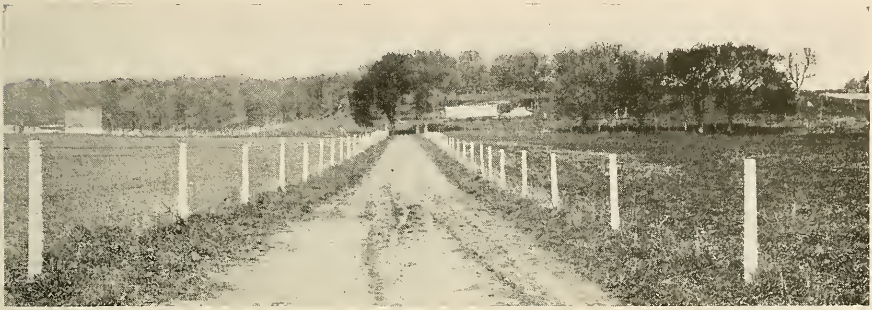


Figure 2. Weeds and rubbish vegetation that grow in the narrow strip along each side of a fence may be burned off without injury to the fence if the posts are of concrete.

Railroads are among the most conservative corporations and do not adopt anything while it is new unless they can quickly prove its advantages. So while railroads some years ago were perhaps slow in giving endorsement to the concrete fence post, they soon recognized its merits and now many railroads consider the concrete fence post as standard for constructing and maintaining their right-of-way fences.

Figure 3. "Nothing but concrete posts on this farm" because they are the most economical. No maintenance required with concrete posts, on farm or railroad.

Although concrete posts have been in use many years, no one has yet determined how long they may be expected to give satisfactory service. There are many engineers and other persons whose opinion is of unquestioned value, who believe that concrete fence posts properly reinforced and made from suitable materials carefully selected and proportioned, should last indefinitely. It is easy to see, therefore, that concrete fence posts are a good investment.

Concrete Posts Must Be Made Properly

Like every other building material, concrete, for best results, must be used in a certain way, and for best results in concrete fence post manufacture, one must carefully observe certain requirements that have been proved necessary to success. Concrete fence posts should be made from concrete mixtures definitely proportioned. Many manufacturers use a 1:2:3 concrete mixture, in which 1 cubic foot of portland cement is combined with 2 cubic feet of clean, coarse sand ranging from the finer particles up to those ¼ inch in greatest dimension, to 3 cubic feet of clean, well graded pebbles or broken stone ranging from ¼ inch up to a maximum of ¾ inch. In some cases fence posts are made from a mixture consisting of 1 cubic foot of cement to 3 cubic feet of sand. There is no excuse for using such a mixture unless suitable clean pebbles or broken stone cannot be obtained, because the 1:3 mixture necessitates more cement to produce strength equal to that obtained by using a 1:2:3 mixture.

Figure 4. Farms bordering on highways protected with fences built with concrete posts are safe against intrusion by passing cattle.

Many persons have the impression that when a definite concrete mixture is specified, they can vary the mixture in certain ways without affecting results. For instance, if a 1:2:3 mixture is recommended, some persons think that the 2 cubic feet of sand and 3 cubic feet of pebbles can be replaced by 5 cubic feet of so-called bank-run material; that is, pebbles and sand as found combined in the usual gravel bank. Practice based on this belief has often been the cause of dissatisfaction with concrete work, not only as applies to the manufacture of fence posts but to other concrete construction as well. Bank-run material varies greatly as regards the volumes of sand and pebbles contained.

and should always be screened before being used in a concrete mixture, by passing over a screen having ⅜-inch meshes, so that the fine and coarse materials (sand and pebbles) can be separated and properly reproportioned to secure a concrete of desired density, hence strength. It may be necessary to screen the pebbles again so that all particles greater than ¾ inch will be thrown out, because this is the maximum size of pebbles or broken stone particles that can be used in a mixture for concrete fence posts on account of the position which the reinforcing rods must occupy. In other words, if larger particles than specified were used, the rods could not be placed as near to the surface as desirable because the pebbles would force the rods farther back from the surface or prevent surrounding them with concrete; in this way some portions of the rods would be exposed.

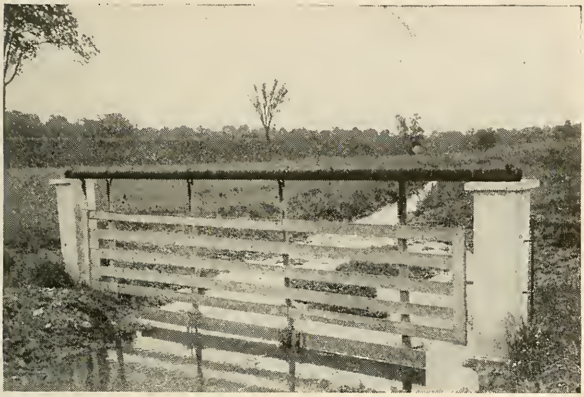


Figure 5. Concrete end posts at water courses hold the fence permanently in line. The suspended gate holds the live stock where it belongs.

Too great emphasis cannot be placed upon the necessity for having the sand and pebbles clean. Any coating on the particles, such as clay, or the presence of loam or other foreign matter in excess of a very small quantity, will prevent the cement from performing its duty of firmly bonding the sand and pebbles together. Sometimes it is necessary to wash sand and pebbles to make them fit for concrete work.

After having selected suitable materials and combined them in proper proportions, sufficient water must be added to form a concrete slightly wetter than what is usually referred to as a "quaky" or jelly-like consistency. Too little water will make it impossible to secure a post of dense texture or structure, while too much water will result in causing the sand-cement mortar to separate from the pebbles, hence the density of the post will not be uniform and there will be air pockets and pebble pockets on the surface and at other places in the post.

Reinforcing Details Are Important

Probably no other essential of concrete post manufacture deserves more careful observance than reinforcing. Reinforcing is the term used to describe the placing of steel rods in proper position in the concrete so that the post will be strong enough to resist strains, regardless of which direction they may come from when the post is set in the fence line. Concrete is a material that, like stone, is very strong in bearing loads that are placed directly upon it; that is, strong in compression as we say, but will not withstand great strains that tend to bend it or pull it apart. In other words, it is relatively weak in tension, so reinforcing must be placed in the concrete to increase the one kind of strength which is low.

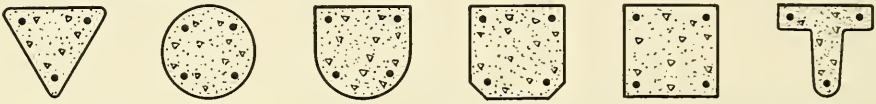


Figure 6. To be effective reinforcing rods must be placed at the points of greatest stress, as shown in these cross-sections.

Some persons have the false impression that a rod or piece of pipe placed at the center of the post accomplishes all that is necessary in the way of reinforcing. This is not correct. One can realize that the strains to which a fence post may be subjected are likely to come from any one of four directions: they may be from either direction along the line of the fence or may be from within or without the enclosure as a result of animals trying to break out or to force an entrance. Experience has proved that, to be effective, the concrete fence post must have the reinforcing properly distributed. This means that in a square post the reinforcing should be placed near the surface at each of the four corners; in a round post, at points in the concrete near the face that would correspond to the outlines of a square; and in a post of triangular shape, near the surface at each corner of the triangle. There are quite a number of shapes for concrete posts other than

Table 1

Materials required for concrete line posts of several dimensions

DIMENSIONS			Volume of Post in Cubic Feet	Weight of Post in Pounds	Amount of Reinforcing Metal Required	MATERIALS						
						1-CEMENT 3-SAND			1-Cement 2-Sand 3-Stone or Pebbles			
						No. Posts Per Barrel Cement	FOR 10 POSTS		No. Posts Per Barrel Cement	FOR 10 POSTS		
Length	Top	Bottom					Sacks Cement	Cu. Ft. Sand		Sacks Cement	Cu. Ft. Sand	Cu. Ft. Pebbles or Stone
7′ 0″	3″x4″	5″x4″	.8	115	Four ¼″ R'nd Rods	14.0	2.8	8.5	19.5	2.1	4.2	6.2
8′ 0″	3″x4″	5″x4″	.9	131		12.3	3.2	9.7	17.1	2.4	4.7	7.1
7′ 0″	4″x4″	5″x5″	1.0	143	Four ⅜″ R'nd Rods	11.3	3.5	10.6	15.8	2.6	5.1	7.7
8′ 0″	4″x4″	5″x5″	1.1	163		9.9	4.0	12.1	13.8	2.9	5.9	8.3
7′ 0″	5″x5″	6″x6″	1.5	213	Four ⅜″ R'nd Rods	7.6	5.3	15.8	10.6	3.8	7.7	11.5
8′ 0″	5″x5″	6″x6″	1.7	243		6.6	6.0	18.0	9.2	4.4	8.8	13.2

those mentioned, which have received more or less popular favor. There is a type corresponding in shape to the ordinary boot heel; another of triangular form but with the points of the triangle rounded rather than quite sharp; while there are rectangular shapes other than square.

Table 1 shows the recommended amount and size of reinforcing rods for the various sizes of posts listed. It will be noticed in this table that the dimensions are for tapered posts and only for posts of square section both at the bottom and top; also that the reinforcing is in every instance specified as round rods.

Attention is called to this for the reason that many persons are under the impression that ordinary wire serves to reinforce concrete fence posts just as well as the special steel rods recommended. This is true only in part, which is when the cross-sectional area and number of the wires used equal the corresponding rods for which they are substituted. Concrete fence posts have been made in which a number of strands of barbed wire have been placed in the concrete as reinforcing. Anyone who has had any experience in fence post manufacture knows the difficulty of keeping the wires in proper position while placing concrete and the many difficulties of handling barbed wire, therefore any person engaged in fence post manufacture, whether for his home needs or commercially, will find that success depends in a large part upon strict observance of the essentials of reinforcing just outlined.

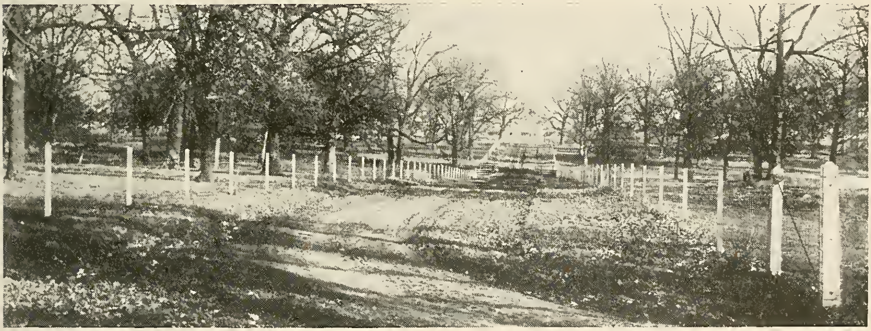


Figure 7. Fences built with concrete posts are permanent improvements that enhance the value of any farm.

Mixing

Although concrete can be successfully mixed by hand, it is not a very difficult job for the home concrete worker to construct a home-made, hand or power-operated mixer, but generally speaking, it will be found far more satisfactory to purchase one of the small commercial machines, when any considerable quantity of posts is to be made.

Many manufacturers of concreting machinery now turn out small and inexpensive, yet efficient power-operated, batch concrete mixers, complete with self-contained gasoline engine. If the home worker has not enough need of one of these to make it desirable to purchase such a machine for his exclusive use, no doubt he will find that enough of his neighbors are interested in concrete work to join with him to secure a mixer which all can arrange to use as needed, thus considerably reducing the cost to each individual of having such a handy outfit available.

In mixing concrete by machine one should be careful to revolve the mixer drum at the speeds recommended by the manufacturer. If revolved too slowly, too long a time will be required for mixing, while if revolved too rapidly the mass of materials will tend to cling to the drum and will not be tumbled about enough to cause thorough mixing. Generally speaking, machine mixing should continue for at least one minute for each batch, after all materials, including water, have been placed in the drum.

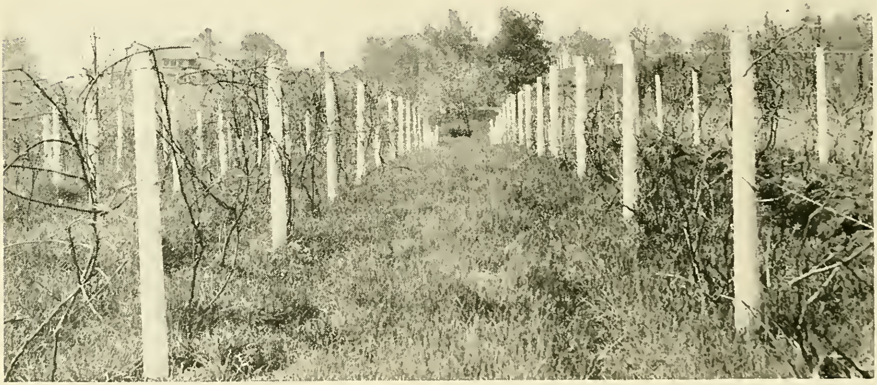


Figure 8. No danger of injuring grapevine roots through periodical resetting of posts if these are of concrete. Concrete posts need be set only once.

Concrete Mixers

Below will be found a list of firms which manufacture small concrete mixers suitable for the home concrete worker's requirements. Any of these concerns will be glad to send their literature on request.

Albany Hardware Specialty Co.....Albany, Wis.
American Cement Machinery Co...Keokuk, Iowa
Archer Iron Works..............2438 W. 34th Place, Chicago
Atlas Engineering Co............Milwaukee, Wis.

Austin Machinery Corporation	Railway Exchange Bldg., Chicago
Blystone Batch Mixer Co.	Cambridge Springs, Pa.
Chain Belt Co.	Milwaukee, Wis.
Equipment Corporation of America	11 S. LaSalle St., Chicago
Lakewood Engineering Co.	Cleveland, Ohio
Milwaukee Concrete Mixer & Machinery Co.	Milwaukee, Wis.
J. B. Foote Co.	Frederickstown, Ohio
Northfield Iron Co.	Northfield, Minn.
Northwestern Steel & Iron Co.	Eau Claire, Wis.
Raber & Lange Manufacturing Co.	Kendallville, Ind.
Ransome Concrete Machinery Co.	Monadnock Block, Chicago
Republic Iron Works	Tecumseh, Mich.
Sheldon Mfg. Co.	Nehawka, Nebr.
Sioux City Engineering & Machinery Co.	Sioux City, Iowa
T. L. Smith Co.	Milwaukee, Wis.
Standard Scale & Supply Co.	169 N. May St., Chicago
Chas. H. Stehling Co.	Milwaukee, Wis.
Waterloo Construction Machy. Co.	Waterloo, Iowa
Oshkosh Manufacturing Co.	Oshkosh, Wis.
Lansing Co.	Lansing, Mich.
Koehring Machine Co.	Milwaukee, Wis.
Ideal Concrete Machinery Co.	Cincinnati, Ohio
W. E. Dunn Manufacturing Co.	Holland, Mich.
Iowa Foundry & Mfg. Co.	Fort Dodge, Iowa
Fairbanks, Morse & Co.	900 S. Wabash Av., Chicago

Molds

There are many types of fence post molds now on the market, none of which is more expensive than the average home worker can afford if he has many posts to make. These are generally constructed of metal and will be found more durable than home-made wood molds,

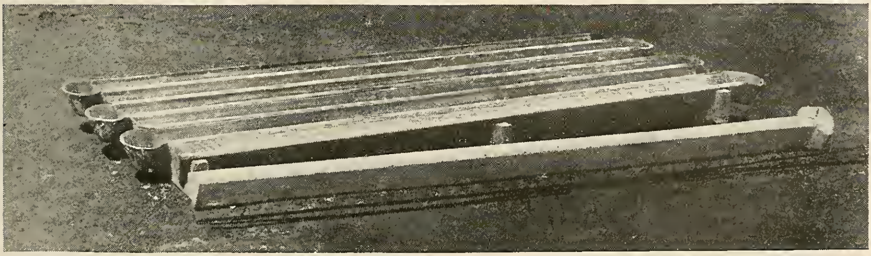


Figure 9. Commercial molds of metal may be used indefinitely. They insure concrete posts of uniform cross-section

two types of which will be described later. But if any one who is about to undertake the manufacture of concrete posts does not feel justified in buying a set of molds for his individual use, no doubt he can find some of his neighbors willing to join with him to secure a set for community use.

Where only a few posts are made, the purchase of one of the commercial molds may not be profitable. In such a case a simple home-made mold such as illustrated in Figure 10 can readily be built. This mold should have sides and ends of 2-inch lumber. The intermediate or partition strips may be made of 1-inch stock of a width corresponding to the size of post being made. The mold may be planned for posts 3 by 4 inches at the top and 5 by 4 inches at the bottom; that is, parallel on two sides and tapered on two sides. Any desired length of post can, of course, be provided for when planning the mold.

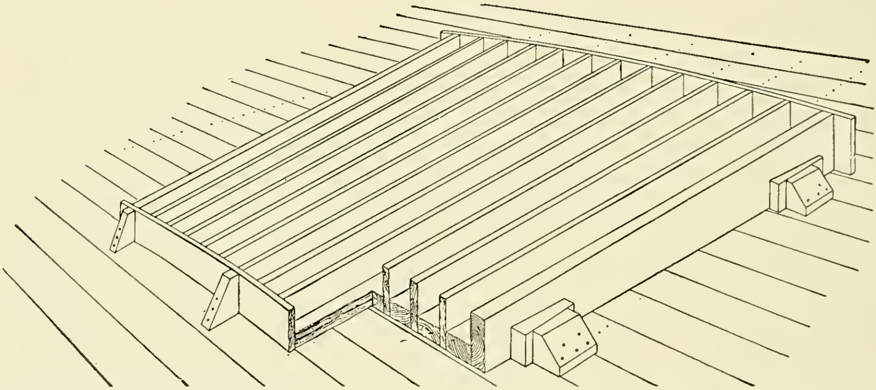


Figure 10. Home-made molds need be limited in size only by the available floor space. In this mold twelve posts can be cast at one time.

In Figure 10 there is shown a gang mold, in which twelve posts can be cast at one time. This mold is planned for a post 4 inches square at the top, 5 inches square at the bottom and 7 feet long, the intermediate strips or partitions and side pieces being cut to such a shape (taper) that the resulting post is tapered on all four sides. A post of this design or shape is often preferred.

When constructing home-made post molds, only clear, straight-grained lumber should be used. To prevent the pieces of which the mold is constructed from warping or bulging out of shape, due to moisture absorbed from the concrete and subsequent drying after the molds are laid away, it is advisable before using the molds the first time, thoroughly to saturate the lumber with a mixture of equal parts of boiled linseed oil and kerosene. This will prevent the lumber from absorbing water from the concrete and will also prevent the concrete from sticking to the mold while posts are hardening.

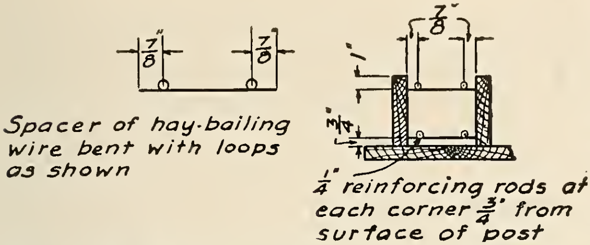

7/8"
7/8
Spacer of hay-bailing wire bent with loops as shown
7/8"
1/4" reinforcing rods at each corner 3/4" from surface of post

Figure 11. Simple spacers for reinforcing rods, to hold them in correct position while placing concrete in the post mold, can readily be made by twisting wire as shown in this illustration.

Filling the Molds

In using the home-made molds illustrated, concrete should be placed as follows: After the molds have been oiled, 1 inch of concrete should be placed evenly at the bottom of the molds, then two reinforcing rods of the proper size and length should be laid in the concrete at the correct distance from the sides of the forms. These rods should be pressed gently into place and held the proper distance from each other and from the sides of the mold by passing over them four or five wire spacers, such as shown in Figure 11. Additional concrete may then be placed up to within three-quarters of an inch of the top of the mold, when the remaining two rods, also with spacers over them, should be placed exactly as were the first two. The remaining space in the mold should then be filled with concrete, and the surface should be smoothed off. Of course the jarring or tapping of the mold and stirring of the concrete should be carried on throughout the entire time concrete is being placed, to release air bubbles and work the coarser particles away from surfaces, producing a smooth finish. Various types of spacers intended to hold reinforcing rods in correct position while placing concrete are now on the market, but the simple device shown serves well for use with the home-made mold described.

Precautions Against Damage

After molds have been filled, they must remain undisturbed until the concrete has hardened sufficiently to permit removing the posts from the molds or the molds from the posts, without damaging them. Under favorable conditions, such as prevail during late spring and summer, blocks and wedges holding the side strips and ends of the mold in position may be loosened and the forms removed at the end of twelve hours. However, as concrete hardens much more slowly in cold than in warm weather, the time mentioned is not invariable, and must be altered in accordance with weather conditions and good judgment. It is important that the concrete shall have hardened sufficiently so that when removing the molds or posts the concrete will not be injured. For this reason the mold should be planned so that wedges and blocks only will be necessary to hold all parts assembled, thus making it possible to take the mold apart with the least amount of hammering.

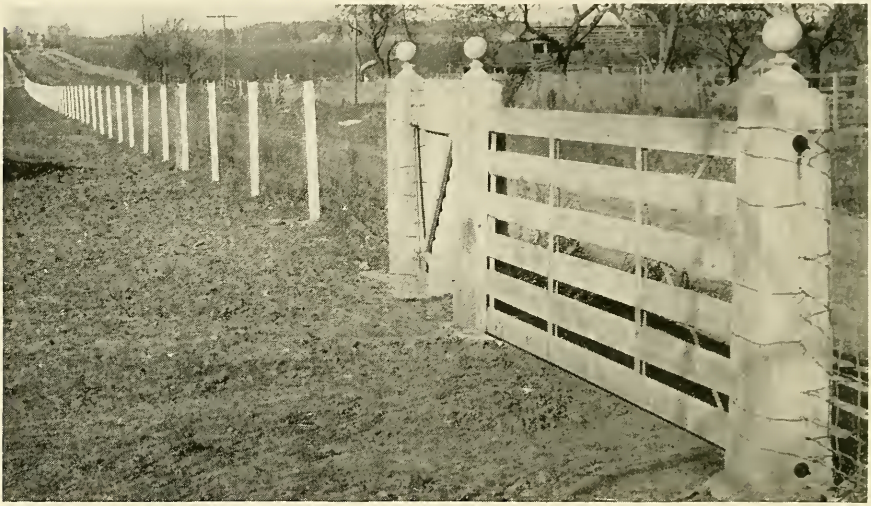


Figure 12. Live stock can be kept where you want it if the barnyard and pasture fences are built with concrete posts.

Curing and Protection

Manufacturers of fence posts usually use every desirable means in the process of manufacture to make certain of best results. Practically every commercial concrete post plant is equipped with special rooms or chambers in which the posts, after being removed from the forms or molds, are placed for proper hardening. These rooms are known as steam hardening chambers and the hardening of the concrete is thus hastened under favorable conditions, by filling these rooms with moist steam. Concrete will harden uniformly and properly only in the presence of a sufficient amount of moisture. If concrete posts, block or similar products when removed from the molds are so stored that they will be subjected to hot wind or sun, then the concrete will dry out instead of harden. As means for hardening concrete fence posts and similar products by steam are usually not within the ability of the home worker to provide, the next best way to make certain that concrete posts will be hardened properly is to protect them from excessive cold, sun and dry winds, and to keep them moist. This can be done by covering them with straw, chaff or similar material after the forms have been removed and keeping this covering wet for a week or ten days. At the end of this time, under favorable temperature conditions the posts will have acquired sufficient strength to permit moving them out of doors where they may then be stood on end resting against a building or wall. They should be placed in piles so that most of the weight is borne by the ground and as little as possible by the posts themselves, as a result of being piled against or on one another. Out of doors they will continue to harden and increase in strength, and under favorable conditions should be strong enough to set in the fence line at the end of thirty days.

Concrete fence posts can be made in winter as well as in summer if certain precautions additional to those already given are observed. These consist essentially of keeping the sand and gravel indoors and free from frost, warming the mixing water, and manufacturing and keeping the posts in a room where the temperature is not lower than 50 degrees until they have gained enough strength to permit storing them out of doors. Further details of concrete post manufacture in winter can be learned from the Portland Cement Association's booklet "Making Concrete and Cement Products in Winter." This will be sent free upon request to any person interested.

How to Attach Line Wire

Many different methods have been used to attach line wires to concrete fence posts. These have included casting staples, eyelets or similar metal fasteners in the concrete, to which there are a number of objections. First, they must be fixed in the post when manufactured and this frequently prevents their being used as intended because it is not always possible to set every post at the same depth in the ground. It is also desirable sometimes to use fencing fabric in which the wires are spaced close together, to make a field or pasture lot hog-tight. Also, fastenings of this kind will in time rust or break off. There is a popular type of concrete fence post now made which contains an insert strip of concrete of such composition that staples may be driven directly into the post.

Sometimes holes are cast in the post and tie wires passed through these holes and around strands of the fencing fabric or fence wires. Unless a post is of fairly large cross-section, however, such holes are quite unlikely to weaken it, and the practice of attaching fencing in this way should be confined to massive end, corner and gate posts.

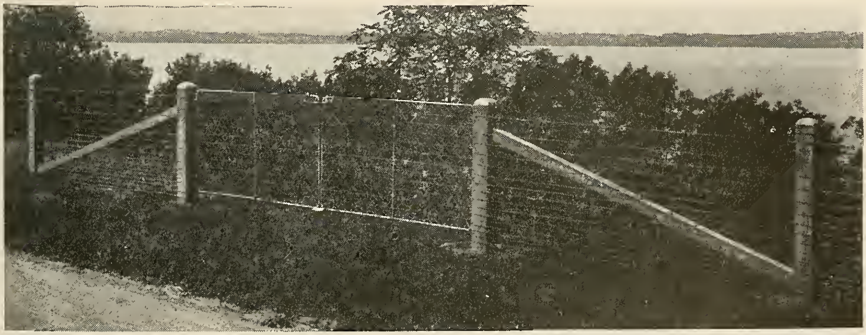


Figure 13. The clean-cut appearance of concrete posts lends attractiveness to any property, in town or country.

One method of attaching line wires that has proved both practical and simple is to tie the wires to the post by wire loops such as are used by telegraph and telephone companies when they attach their wires to the glass insulators on telegraph or telephone poles. A loop of wire is passed around three sides of the post, this loop being long enough so that the two projecting ends which extend beyond the post may be wrapped around the line wire or around a strand of the woven fence fabric. This method of attaching fencing wire is usually referred to as the "Western Union twist."

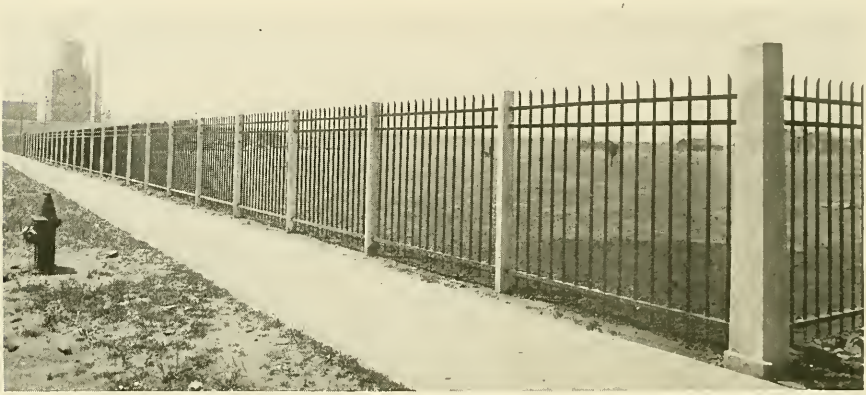


Figure 14. Concrete posts are a source of constant protection to industrial plants.

Commercial Post Molds

If one is considering the manufacture of a considerable quantity of concrete fence posts, purchase of the commercial steel molds and post making tools will be found true economy. The following named firms issue printed literature on fence post molds and post making tools. Any of these firms will be glad to send full information as to their products upon request.

American Cement Machine Co.	Keokuk, Iowa
Automatic Sealing Vault Co.	Peru, Ind.
D. & A. Post Mold Co.	Three Rivers, Mich.
Hotchkiss Lock Metal Form Co.	Binghampton, N. Y.
Ideal Concrete Machinery Co.	Cincinnati, Ohio
Milwaukee Post Mold Co.	Milwaukee, Wis.
National Concrete Machinery Co.	Madison, Wis.
Northwestern Steel & Iron Works	Eau Claire, Wis.
Ohio Post Mold Co.	Nicholas Bldg., Toledo, O.
Raber & Lang	Kendallville, Ind.
Staple Post Mold Co.	Westerville, O.
Universal Cement Post Mold Co.	Morristown, Ind.

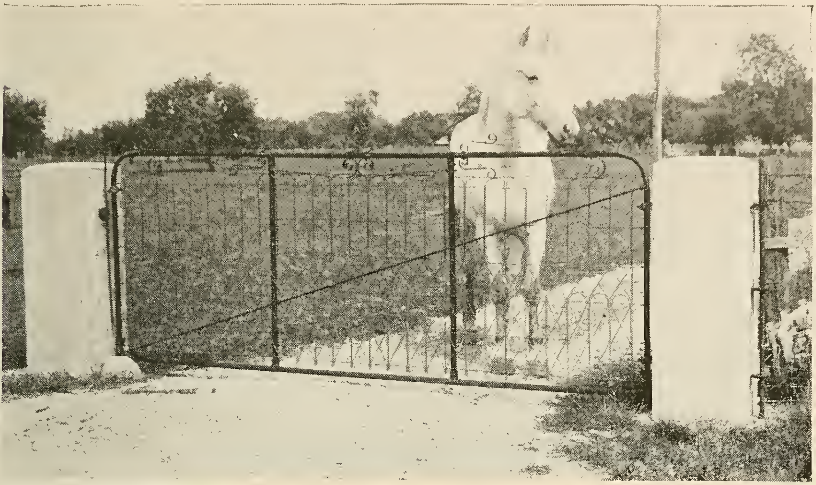


Figure 15. Concrete gate posts built like these will resist all the severe strains and shocks that posts in this position must withstand

Concrete End Posts and Concrete Posts for Gateways

Concrete posts at the ends or corners of fence lines are subjected to great strains. They must resist practically all of the pull exerted by tightening the line wires in the fence; therefore, it is necessary that they be made larger. Naturally they must also contain a correspondingly increased amount of reinforcing metal. The same applies to gate posts or posts that serve to provide entranceways to a field or inclosure, because they must bear the load of gates hung to them, in addition to the strain or pull of fence wires or fabric stretched from them. Sometimes it is necessary to provide concrete bases or footings to keep end, corner and gate posts in proper position. On account of the increased size and weight of such posts, it is usually found most convenient to build them in place. They may, however, be made at some central point and hauled to place and set by means of a simple derrick, after they have thoroughly hardened.

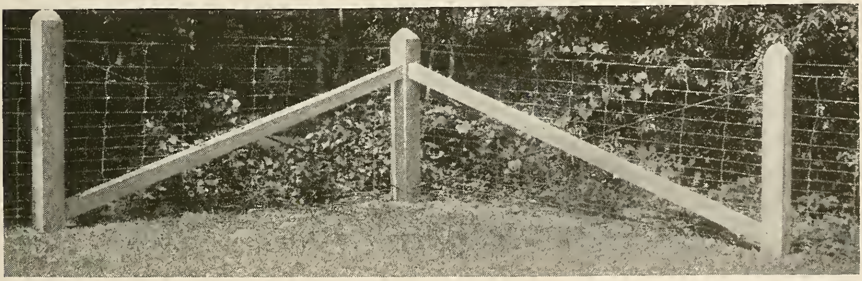


Figure 16. Once they are placed, concrete corner posts braced like this need no further attention

Table 2 suggests various dimensions suited to corner posts. Which size to select will depend upon the length of fence line to be stretched from such posts. The table shows volume in cubic feet, approximate weight in pounds and the amount of reinforcing steel required for the various sizes of posts listed. Some of the smaller sizes are suitable for clothes line and arbor posts. Quantities of materials necessary to make two different mixes are also shown.

As in the manufacture of ordinary concrete line posts, the 1:2:3 mixture will be found preferable to the 1:3 mixture, in which the 3 cubic feet represents sand only. Concrete for corner posts, end posts, gate posts, etc., should be mixed to the same consistency as recommended for line posts, and the same care should be used in placing the reinforcement. This must extend from the bottom of the post to the top, not from ground line or from a point slightly below, because unless reinforced from end to end, the strains of the fence or load of gates would cause the post to snap off where the reinforcement ended. Rods smaller than ⅜ inch in diameter should not be used in corner posts for the simple reason that too many would be required to provide the necessary strength and consequently they would be so closely spaced that they would interfere with placing the concrete.

Table 2

Dimensions of corner posts and materials needed

DIMENSIONS		Volume of Posts in Cu. Ft.	Weight of Posts in Pounds	Amount of Reinforcing Metal Required for Each Post	MATERIALS						
					1-Cement 3-Sand			1-Cement 2-Sand 3-Pebbles or Stone			
					No. Posts Per Barrel Cement	For 1 Post		No. Posts Per Barrel Cement	For 1 Post		
Length	Size					Sacks Cement	Cu. Ft. Sand		Sacks Cement	Sand Cu. Ft.	Pebbles Cu. Ft
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
8′ 0″	6″x 6″	2.0	288	Four	5.6	.7	2.1	7.8	.5	1.0	1.6
8′ 0″	7″x 7″	2.7	392	½″	4.1	.95	2.9	5.7	.7	1.4	2.1
8′ 6″	7″x 7″	2.9	416	Round Rods	3.9	1.0	3.1	5.4	.8	1.5	2.2
8′ 0″	8″x 8″	3.6	512	Four	3.1	1.3	3.8	4.4	.9	1.8	2.8
8′ 6″	8″x 8″	3.8	544	⅝″	3.0	1.35	4.0	4.1	1.0	2.0	2.9
9′ 0″	8″x 8″	4.0	575	Round Rods	2.8	1.4	4.3	3.9	1.1	2.1	3.1
8′ 0″	10″x10″	5.6	799	Four	2.0	2.0	5.9	2.8	1.4	2.9	4.3
8′ 6″	10″x10″	5.9	850	¾″	1.9	2.1	6.3	2.6	1.5	3.1	4.6
9′ 0″	10″x10″	6.2	899	Round Rods	1.8	2.2	6.7	2.5	1.6	3.2	4.9
10′ 0″	5″x 5″	1.7	250	Four ⅜″	6.4	.6	1.9	9.0	.4	.9	1.4
12′ 0″	5″x 5″	2.1	300	Round Rods	5.4	.7	2.2	7.5	.5	1.1	1.6

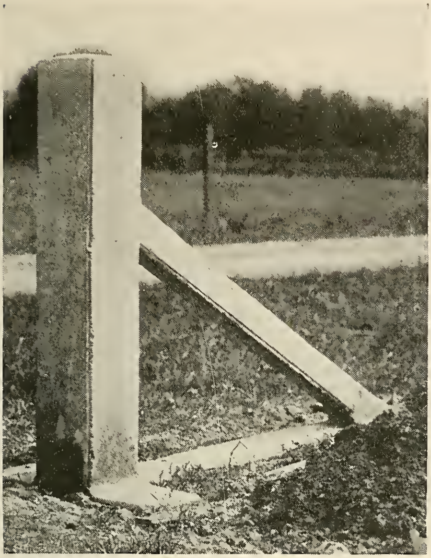


Figure 17. Concrete end post with brace cast monolithic with the post. Such construction is rigid enough to stand almost any fence strain that can be put upon it.

Special care should be taken when making end posts, corner posts and gate posts in place, that if the work is done during cool weather the concrete is protected from any possibility of freezing and from rapid drying out, also that the posts will not be subjected to the strains which they are intended to finally bear until the concrete has hardened to a degree beyond all possibility of injury after the posts are put to actual use. Fencing should not be fastened to such posts until they have had at least thirty days to harden under favorable conditions.

For several days after placing the concrete, the forms should be left in place as a protective covering. Then when forms are removed the post should be covered with wet burlap or canvas and both concrete and protective covering be sprinkled several times daily so that there will be a proper amount of moisture always present to assist the concrete to harden under favorable conditions.

Corner posts and end posts, whether cast in place or not, must of course be provided with braces unless the posts themselves are made so unusually massive and are so strongly reinforced and set so deep in the ground as to make bracing unnecessary. Economy, however, will point to the advantage of using braces instead of massive construction. In many cases end posts and corner posts with braces are cast solid, that is, monolithic. Braces also should be properly reinforced.

Any farmer who has had experience with wood end posts has been troubled by having them pull

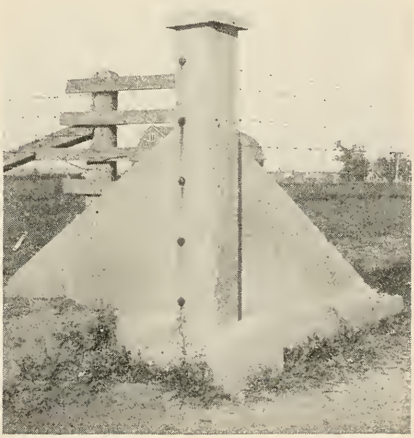
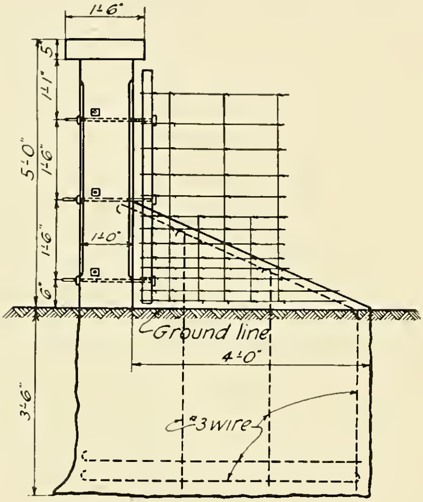


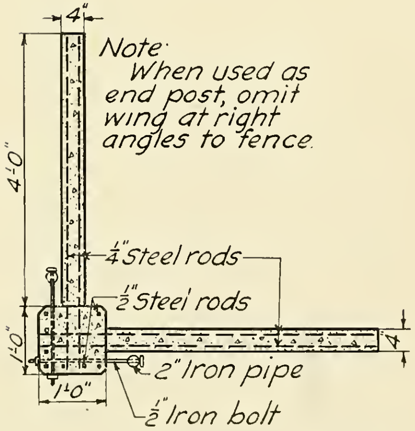
Figure 18. Corner post with braces cast solid with it. Details shown in Figure 19.

out of the ground from the strain of the fence. This is due usually to too short a brace or to placing the brace at an improper point along the height of the post, or to both of these causes. The brace should be placed in line with the fence so that it will bear against the post at a point not more than two-thirds of the distance from ground level to the top of the post. Of course corner posts require bracing against the pulling forces from two directions along the fence line.

Concrete gate posts may be made quite attractive by giving a little thought to planning the forms or the method of construction. Concrete block may be used to advantage for this purpose and the post may be securely reinforced and made practically monolithic by inserting rods in the core spaces of the block and then filling these spaces with a "quaky," rich concrete. In laying up block to make corner posts, the block should be well wet before laying and a rich mortar, mixed in the proportion of 1 sack of portland cement to 2 cubic feet of clean, coarse sand, should be used to bed them. Provision must be made when building gate posts properly to embed the fittings necessary to receive the gate hinges.



ELEVATION



Note
When used as end post, omit wing at right angles to fence.

SECTION

Figure 19. Cross-section and elevation of solid concrete corner post and brace shown in Figure 18. Designed by Iowa State College.

Sometimes this may perhaps be best arranged for by setting a pipe sleeve in the concrete when placed, and then passing through this pipe the hanger that is to receive the eye of the gate hinge, the hanger being threaded on the end passed through the pipe so a nut can be applied.

Very pleasing effects can be obtained in gate post construction by selecting clean rubble stones, or "niggerheads" as they are sometimes called, laying these around the inside of the form against the form face, and filling in behind them with a rich "quaky" concrete. Reinforcing rods, of course, must be used, the size of which will depend upon the massiveness of the construction and the weight of gates which the posts must carry.

Attractive surface finish can be given to monolithic concrete gate posts by using a special facing mixture containing selected colored stone chips, such as pink granite, white or yellow marble, slag, or a mixture of several of these, and sometimes adding a little micaspar to the mixture. The interior of the post is made of the usual 1:2:3 concrete. When the concrete has hardened sufficiently to permit removing the forms, the surface film of cement that coats the particles of selected materials in the facing mixture can be scrubbed off by using a stiff bristle or wire brush and water, thus exposing these particles and giving a very attractive surface finish. The possible variations of treatment of this kind are limited only by the experience and ingenuity of the individual worker. If when forms are removed, the concrete has hardened to such a degree that washing with a brush and water will not remove the surface film of cement, it is then necessary first to scrub the post with a solution consisting of 1 part of common muriatic acid to 3 or 4 parts of water. The surface should be gone over quickly with this solution and no more applied than necessary to remove the surface coating of cement. If more than this is done the acid mixture will tend to loosen the stone chips in the concrete. Immediately following the acid washing, the surface should be drenched thoroughly with clean water to remove all traces of acid.

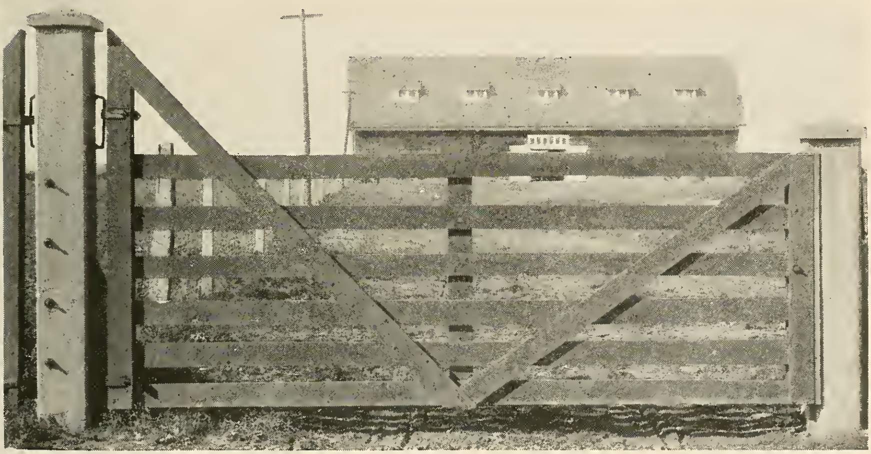
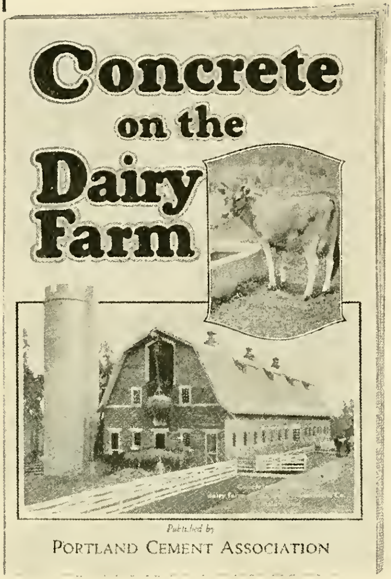


Figure 20. Gates hung from rigid well-braced concrete gate posts will not sag.

These Books Will Help You Make Your Farm Pay



Concrete on the Dairy Farm

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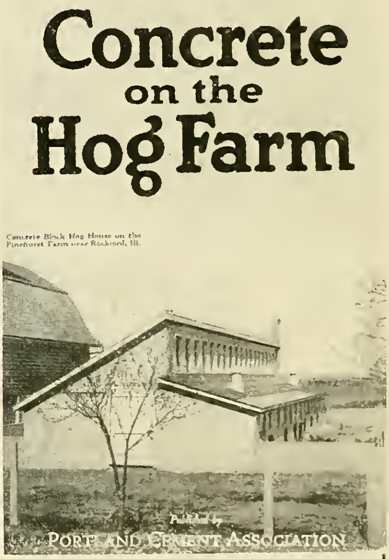
Every dairy farmer needs germproof, fireproof, rotproof buildings to help produce a high quality milk at low cost. Concrete improvements is the answer. Our booklet, "Concrete on the Dairy Farm," tells how and why. If you are a dairy farmer you will want this book.



Concrete on the Hog Farm

Concrete Block Hog House on the Pinehurst Farm near Rockford, Ill.

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Hog raising is a profitable business if conducted in a business-like manner with permanent, expense-proof, sanitary structures. Then the hogs thrive and the farm pays. If you are a hog raiser, get our booklet, "Concrete on the Hog Farm." It shows how concrete can help you make money.

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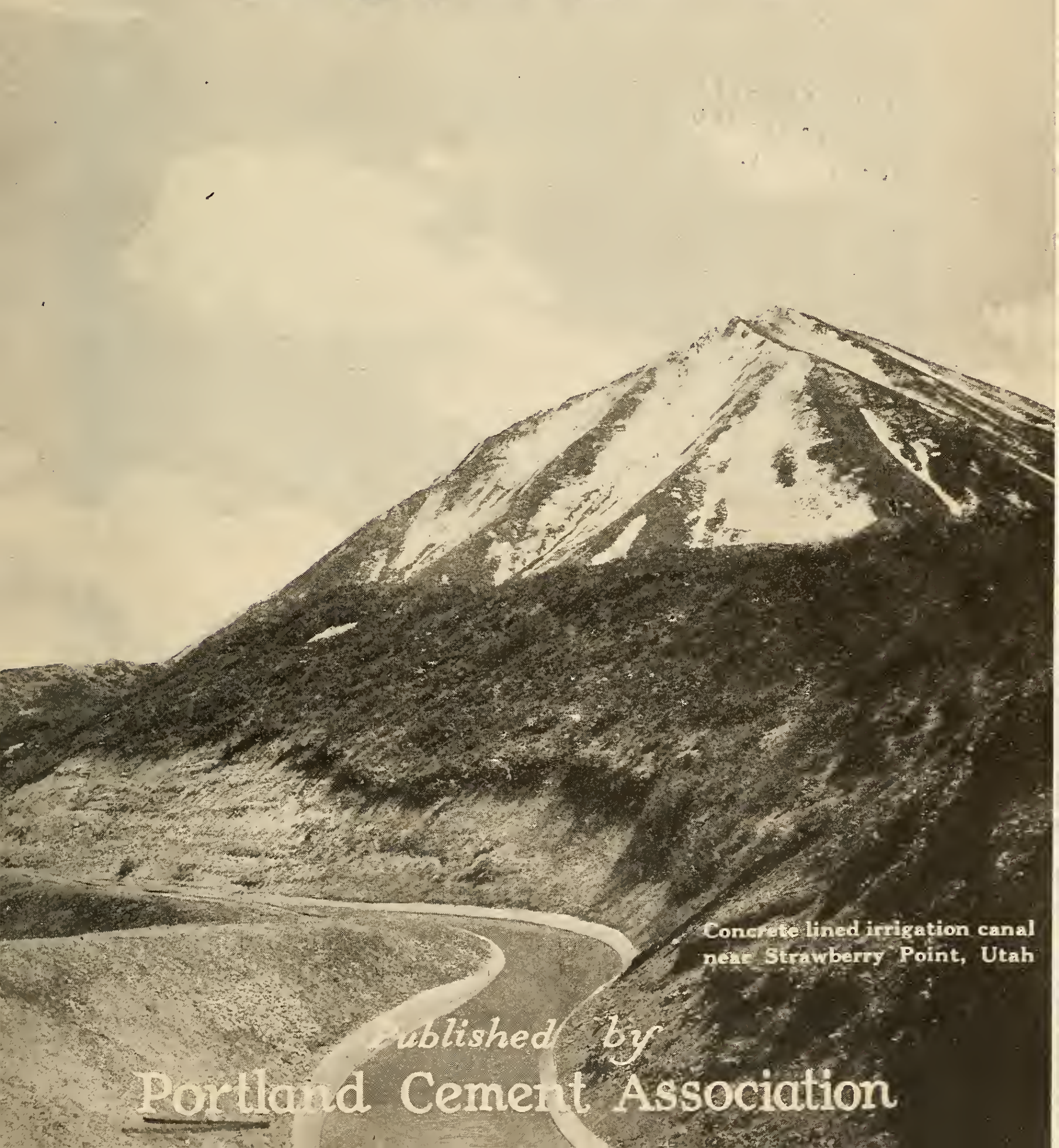
CONCRETE *for* IRRIGATION CANALS



Concrete lined irrigation canal near Strawberry Point, Utah

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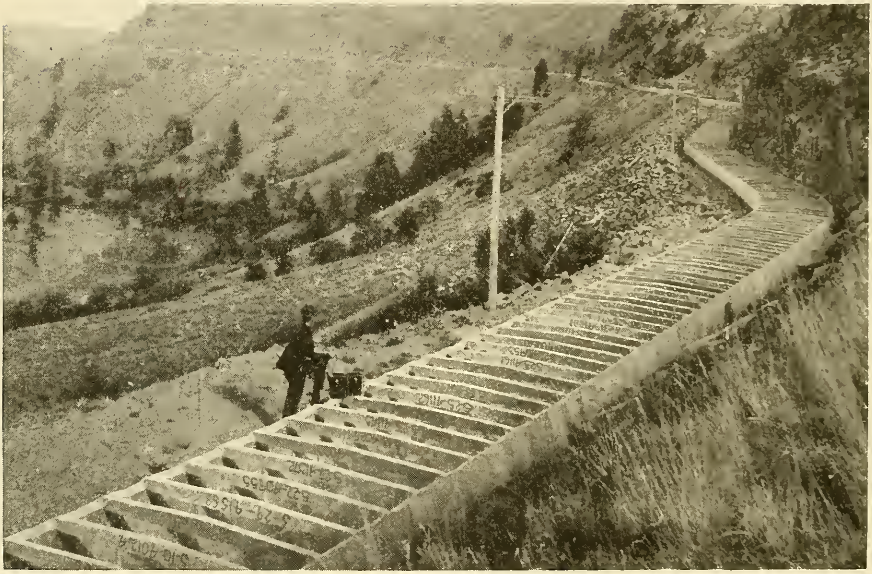
Concrete *for* Irrigation Canals

EVER since the U. S. Reclamation Service began systematically to impound and distribute water to reclaim the arid and semiarid lands of the west, concrete has been used successfully in steadily increasing quantity in the construction of dams, canals, flumes and other irrigation structures.

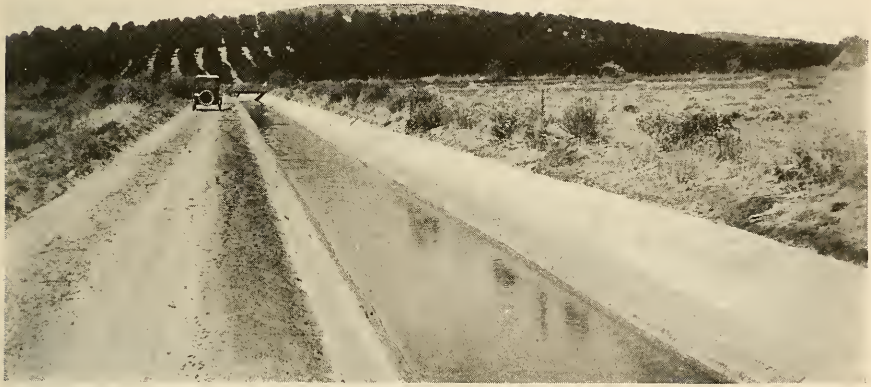


The Tieton Main Canal, Yakima Project, U. S. Reclamation Service, North Yakima, Wash. Soil conditions which compelled the use of a minimum volume of lining made it advisable to use precast concrete units.

The loss of water through seepage in earth canals is always very great. It was the custom in early developments to install wood linings to stop the most serious leaks if lumber was readily obtainable in the district, but this proved expensive and inefficient because of the short life of timber construction and the high cost of maintenance. For many years past the use of concrete for the construction and lining of canals has found increasing favor among irrigation engineers. This material is now generally recognized as possessing more desirable qualities than any other material used for the purpose.

Advantages of Concrete Linings for Irrigation Canals

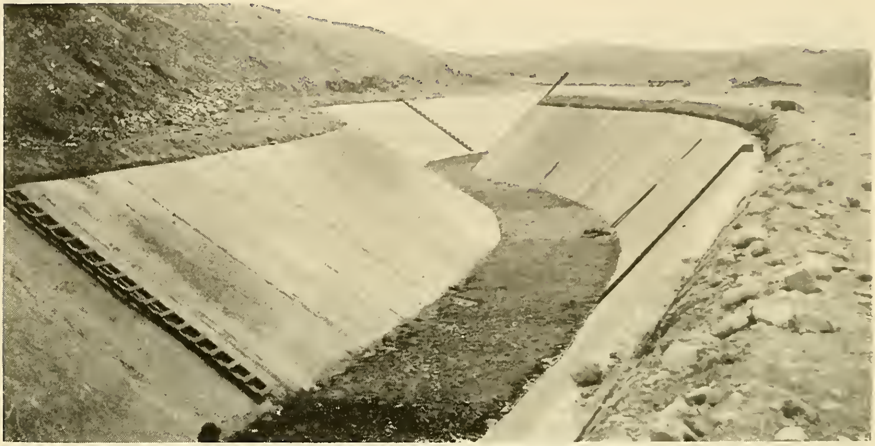
In most cases the number of acres that may be irrigated in any project is governed by the amount of water available. Loss of water through seepage means a direct reduction in crop-producing acreage. It is only the water actually distributed over the land to be cultivated that contributes to crop raising. Some water necessarily must be lost through evaporation. Seepage losses, however, can be effectively eliminated by lining canals and ditches with an impervious material, like concrete. The U. S. Department of Agriculture estimates that as much as forty per cent of the water entering an unlined canal or ditch is lost by seepage into the earth banks. The total amount lost in any particular case varies with the length of the canal and the character of the soil through which it passes. Probably the average loss is between twenty-five and forty per cent. For every 900 acres of land irrigated in a system where there is a seepage loss of forty per cent, 1.500 acres could be irrigated if loss through seepage were prevented. In other words, with a given amount of water, prevention of seepage losses would increase the capacity of such a system sixty-six and two-thirds per cent.



A section of the Riverside Water Company's canal, Riverside, Calif., lined with concrete. This lining has given satisfactory service for 25 years.

An Example of the Profit from Concrete Linings

Users of water from the Orland project, U. S. Reclamation Service, Glenn County, Calif., in the spring of 1918 entered into a contract with the Secretary of the Interior to line with concrete almost the whole distributing system of this project. This involved about seventy miles of canals and laterals, calling for the placing of about 650,000 square yards of concrete lining. Native land in the Orland project before irrigated could be bought for $100 per acre. After it had been prepared for cultivation, irrigated and improved with fences and buildings, the valuation ranged from $350 to $500 per acre. When planted to orchard and with trees of bearing age, this land had a valuation ranging from $1,000 to $2,000 per acre. With such a valuation, it can readily be understood why the farmers wanted an efficient distributing system such as that made possible by concrete-lined canals.



Partly completed canal on the Spring Valley Division of the Sun River Project, Montana. Loss of water by seepage, sometimes as high as 40 per cent, is prevented by concrete linings.

Concrete-lined canal on Delaney Lake fill, Turlock Irrigation District, Turlock, Calif. Concrete linings reduce the possibility of breaks in the banks.

Concrete Linings Reduce Danger of Breaks in Banks

There is always the possibility that the banks of unlined ditches may give way, thus putting an entire irrigation system or a large portion of it out of commission until repairs can be made. Such breaks are usually expensive at any time, but particularly so if they occur when water is most needed for crops. In such cases the loss due to lack of water is generally far greater than the actual cost of repairs to the canal. An instance of this kind occurred in the unlined Turlock canal in California. The cause of the break apparently was due to the burrowing of gophers into the canal banks, thus causing a leak which finally resulted in the washing away of about 100 feet of canal embankment. In this instance the canal was out of service for six weeks at a time when water was most needed for crops. The cost of actual repairs to the canal was $20,000, but the estimated damage in crop losses was $1,000,000. Had this canal been lined with concrete, the washout would not have occurred.

Concrete flume in a private orchard irrigation system at Pomona, Calif.,—a permanent improvement increasing land values.

Flume for orchard irrigation made of spalls, split granite, cobbles and small boulders lined with concrete, Redlands, Calif.

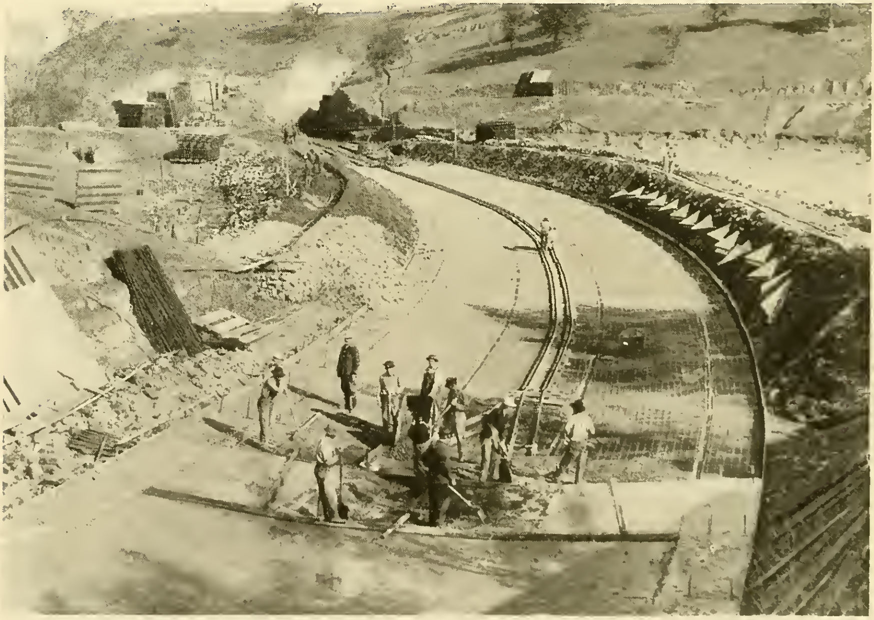
Concrete Linings Increase Capacity of Canals

Owing to the even, regular surface of concrete lining, little resistance is offered to the flow of water and its velocity is consequently more rapid in the concrete lined canal than in one with earth banks. Vegetation often becomes rank on the sides and bottom of unlined canals. This further retards the flow of water. Deposits of silt and other matter in unlined canals also retard the rate of flow and reduce the original capacity. The following table is presented to illustrate the comparative efficiency of lined and unlined canals.

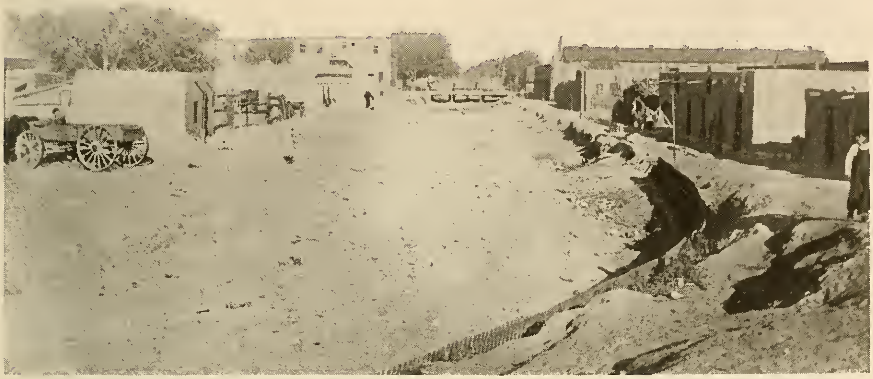
The figures show the volume of water in cubic feet per hour and acre feet per hour carried by lined and unlined canals, similar in every respect except for the linings. Kutter's formula, which is accepted as standard for computing the rate of flow in canals, was used in making these calculations. The co-efficient of friction for unlined canals was taken as (n = .03) and for concrete-lined canals (n = .011).

Table showing the Relative Volume of Water Carried in One Hour in Concrete Lined and Unlined Canals, assuming an average depth of 4 feet.

Dimensions		S Ratio of fall to length	Volume of Water Cu. Ft. Per Hour		Volume of Water Acre Ft. Per Hour	
Width of Bottom	Slope of Sides		Concrete Lined	Unlined	Concrete Lined	Unlined
2 feet	1:1	.001	604,800	86,400	13.8	1.98
4 feet	1:1	.001	828,000	115,000	19.0	2.64
6 feet	1:1	.001	1,123,000	144,000	25.8	3.30
8 feet	1:1	.001	1,404,000	173,000	32.2	3.97



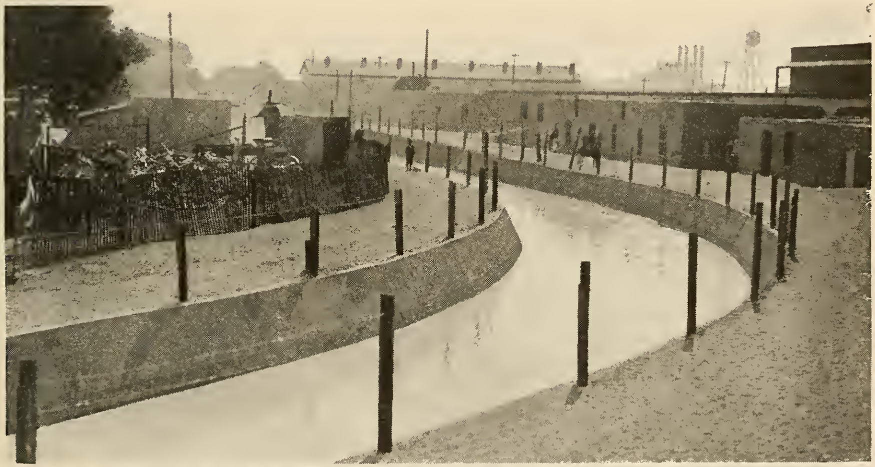
Turlock Irrigation District, Turlock, Calif. Delaney Lake fill in course of construction, showing method of placing reinforced concrete floor. Steel anchor rods are shown in place for continuing reinforcement through concrete wall linings.



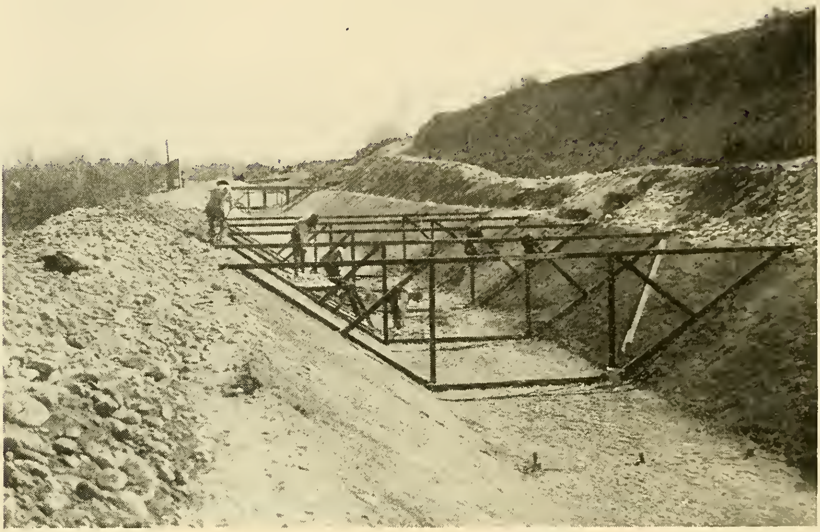
Franklin Canal, U. S. Reclamation Service, Rio Grande Project, El Paso, Texas, before lining with concrete—a ragged, poorly defined water course from which there were large and constant losses of water through seepage.

Concrete Linings Decrease Cost of Excavation

Since lining a canal with concrete greatly increases its water-carrying capacity, a canal of smaller cross sectional area will serve for supplying a given amount of water, therefore less excavation will be necessary. With a much more rapid flow of water permissible, the concrete-lined channel may have a greater gradient and consequently may follow more closely the contour of the land than the unlined channel, thus reducing still further the amount of excavation required.



Franklin Canal, El Paso, Texas, after being lined with concrete—an improvement which confines the water flow, prevents seepage and erosion of the banks and improves the general appearance of the surroundings.



Templates used in preparing the earth section for concrete lining, Ridenbaugh Canal, Boise, Idaho.

A completed section of concrete lining, Ridenbaugh Canal, Boise, Idaho.

Concrete-Lined Canals Have Low Maintenance Cost

Vegetation which grows on the bottom and sides of unlined canals must be cleaned out at least once each year at considerable expense. Irrigation authorities estimate that ninety per cent of the cost of cleaning out canals is eliminated by concrete lining. This saving alone over a period of twenty years is often sufficient to pay for such a lining.

Reverse curves on the high line, Strawberry Valley Project, Utah. Concrete lining decreases excavation costs and permits advantageous locations.

The maintenance cost of unlined canals is heavy in those parts of the country where the slope is considerable. Water flowing at high velocities has great scouring action. If there are sharp curves in the canals, banks are likely to be undercut, or if the canal follows a hillside, the bank on the lower side may be washed out. Rapidly flowing water carries a large amount of sediment which is likely to be deposited at bends or in stretches of the canal where velocity is checked. Such deposits must be removed, otherwise the water-carrying capacity of the canal will be greatly reduced.

High line on the Strawberry Valley Project, Utah. Water from the snow covered mountains is conveyed to the valley, converting it into a garden spot. A typical joint for a concrete-lined canal is shown in the foreground.

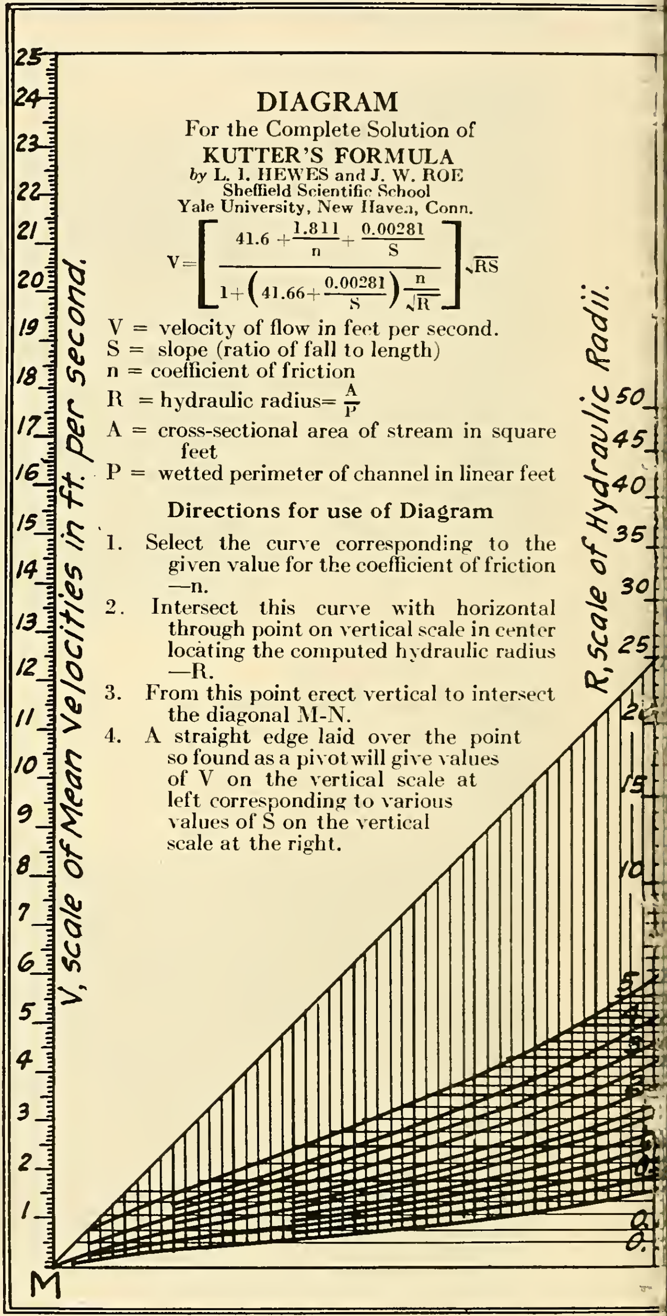
Uniform Distribution of Water Insured by Concrete Lining

Enormous quantities of water are lost through seepage into the sides and bottom of unlined canals. This tends to raise the water table in the soil, flooding certain sections of a district while depriving other sections of a sufficient supply of water. When canals and their laterals are lined with concrete, the water available is distributed evenly and economically over the entire area of a district as planned.

Some Things to Bear in Mind when Laying Out Canals and Lining Them with Concrete

Every irrigation project has its peculiar problems. The design of canals depends upon so many factors that each problem must be solved independently, and in the light of what seems to be the best practice in each case. The same fundamental principles, however, apply to the use of concrete in irrigation structures as apply to any other use of concrete. When concrete linings have failed, such failure has invariably been traced either to faulty methods of design, inferior materials or careless workmanship in construction.

Any brand of portland cement may be used which meets the specification requirements of the American Society for Testing Materials. Sand and pebbles or broken stone should be carefully selected. Our booklet, "How to Make and Use Concrete," goes into the fundamentals of selecting, proportioning and mixing concrete



DIAGRAM

For the Complete Solution of

KUTTER'S FORMULA

by L. I. HEWES and J. W. ROE

Sheffield Scientific School

Yale University, New Haven, Conn.

$$V=\left[\frac{41.6+\frac{1.811}{n}+\frac{0.00281}{S}}{1+\left(41.66+\frac{0.00281}{S}\right)\frac{n}{\sqrt{R}}}\right]\sqrt{RS}$$

V = velocity of flow in feet per second.

S = slope (ratio of fall to length)

n = coefficient of friction

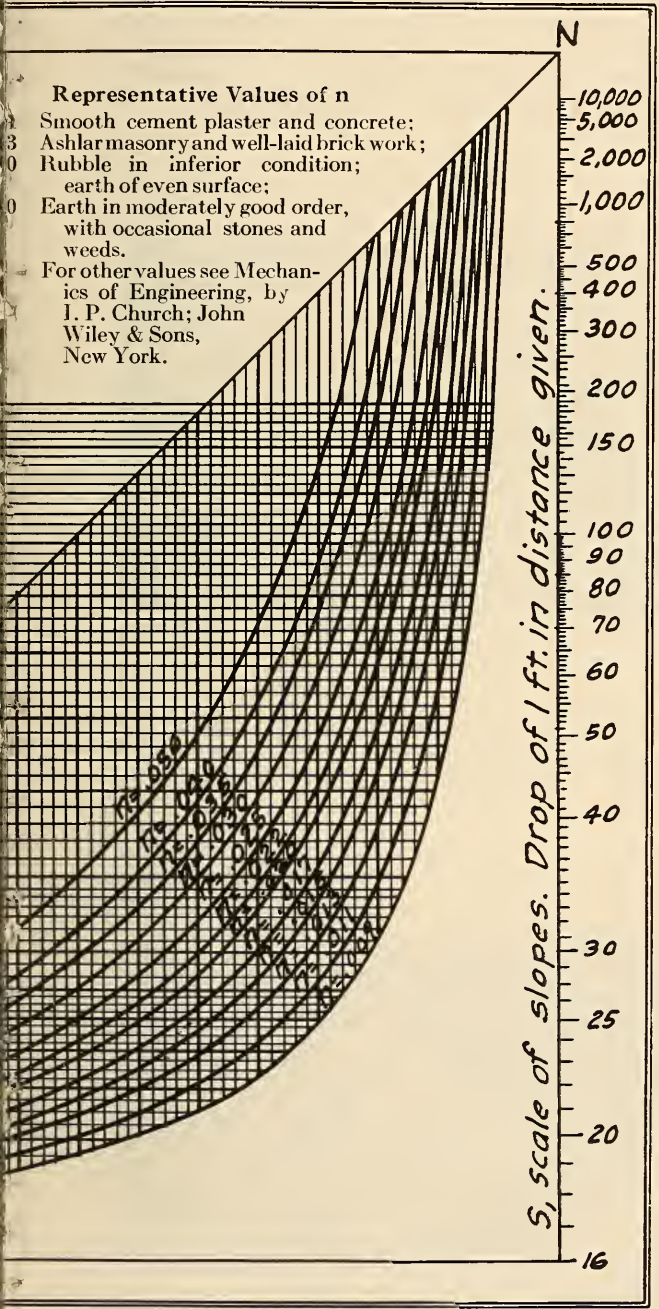
R = hydraulic radius $=\frac{A}{P}$

A = cross-sectional area of stream in square feet

P = wetted perimeter of channel in linear feet

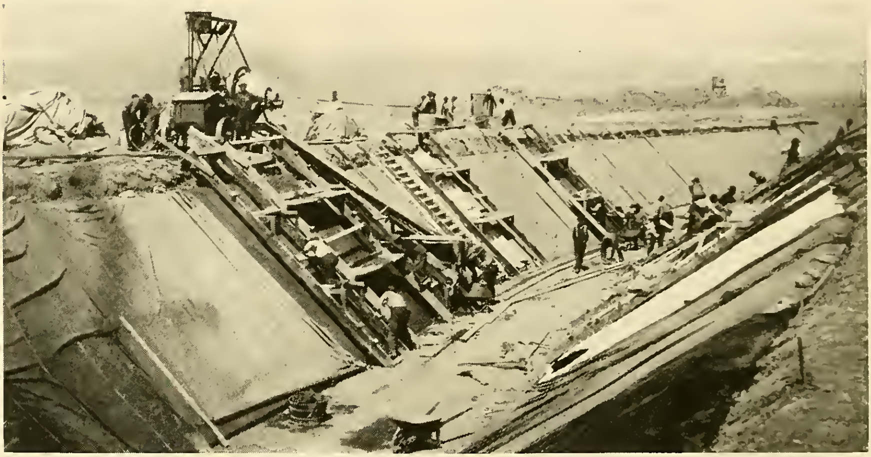
Directions for use of Diagram

1. Select the curve corresponding to the given value for the coefficient of friction —n.
2. Intersect this curve with horizontal through point on vertical scale in center locating the computed hydraulic radius —R.
3. From this point erect vertical to intersect the diagonal M-N.
4. A straight edge laid over the point so found as a pivot will give values of V on the vertical scale at left corresponding to various values of S on the vertical scale at the right.



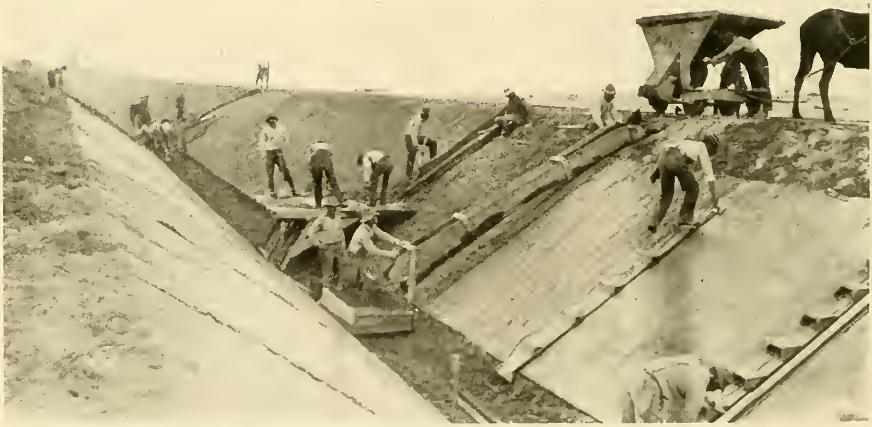
materials. A copy will be sent on request. Sand should be coarse, clean, well graded, free from alkali and should pass through a screen having 4 meshes to the linear inch. If sand of suitable grading and other qualities is found at or near alkali deposits, it should be washed thoroughly with clean water to remove alkali before being used for making concrete. Pebbles or broken stone should be clean, hard, durable and uniformly graded from ¼ inch up to a maximum dimension of 1½ inches. In all cases the correct proportions of cement, sand and pebbles or broken stone should be determined by field tests, so that the densest possible concrete will be obtained. If the sand and pebbles or broken stone are properly graded, a mixture of one sack of portland cement to two cubic feet of sand and three cubic feet of pebbles or broken stone, with the correct amount of water, will produce a concrete having the required strength and watertightness. The correctly proportioned ingredients should be thoroughly mixed, only enough water being used to produce a plastic mass that can easily be handled, yet will not flow out of place on the bank slopes.

Care must be taken to protect newly placed concrete from hot sun, drying wind and other influences that would cause it to dry out rapidly. Some kind of a protective covering, such as a layer of earth or a shelter of canvas should be used to prevent evaporation of water from the concrete and its surface must be kept wet by sprinkling or in some other manner for several days following completion.

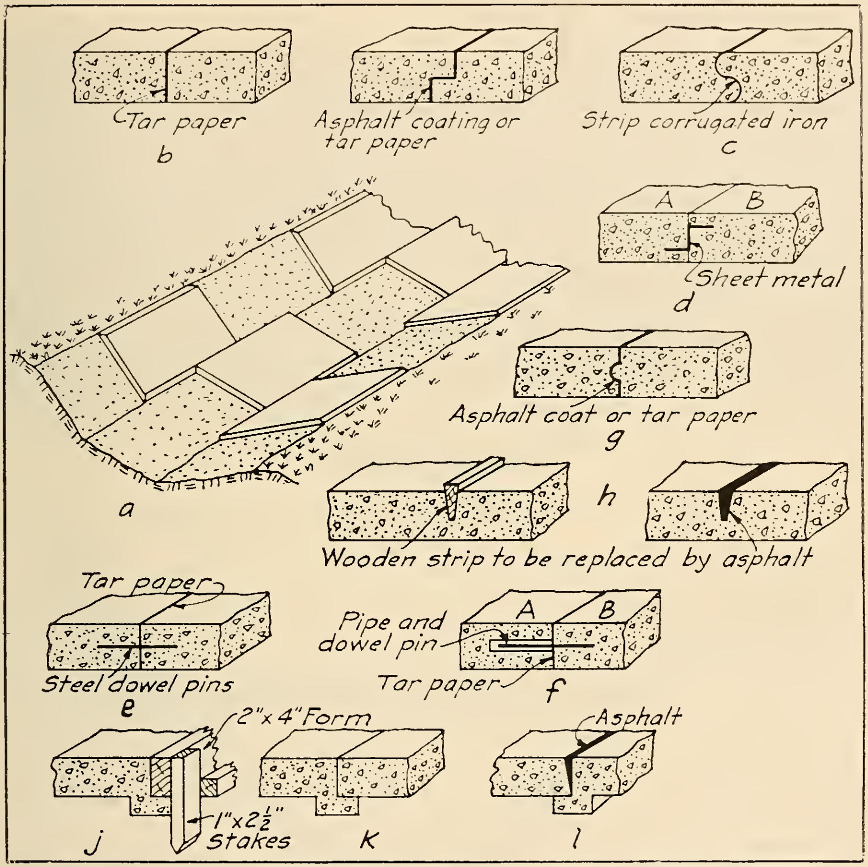


Finishing an intermediate section of the lining for Los Angeles, California, aqueduct. The finished sections of the lining were protected by canvas covers and kept wet by continuous sprinkling until thoroughly cured.

Certain conditions may necessitate reinforcing the concrete. Where concrete linings are laid on firm soil, reinforcing may not be necessary. On unstable soil, reinforcing is advisable as it will assist greatly in preventing cracks due to possible settlement. Canals and ditches should not be located on or through an earth fill if this can be avoided.



Western Extension Canal, Umatilla Project, Oregon, being lined with concrete. The banks are sloped and the concrete is applied without forms. The concrete is chuted from car to a receiving box and then shoveled to a platform and into place.



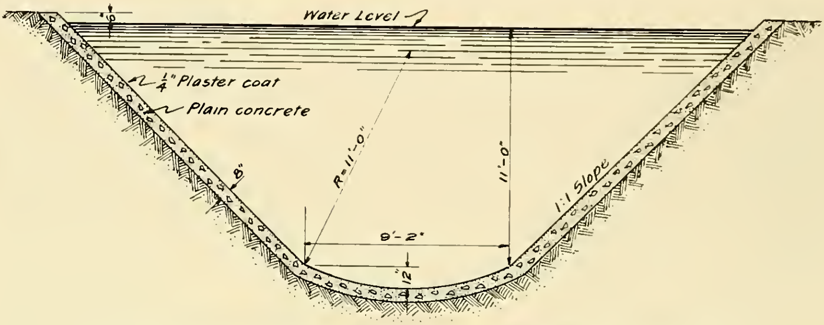
Typical joints for concrete canal linings. Method of staggering intermediate sections on concrete linings is shown (figure a). A plain abutting joint (figure b). This joint is frequently modified by introducing one or more plies of tar paper. Offset joint (figure j, k and l) is easily made. Form for making this joint shown in figure j. Use of tar paper in joints is quite common.

Expansion Joints

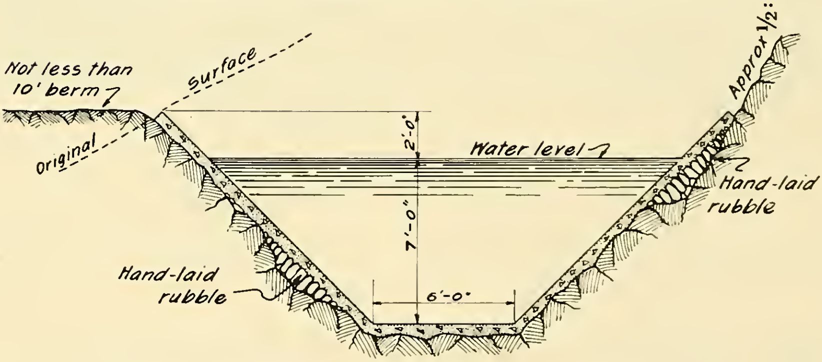
To provide for volume changes of the concrete under changing conditions, joints in concrete linings are necessary to prevent cracks. A good joint should permit expansion and contraction to occur without disturbing the continuity of the lining by too wide a joint space, and should also permit a certain amount of creeping without misplacement. Typical joints used in various irrigation systems are shown above. In large and important canals the joint *j. k. l.* should be used for best results. A less expensive form of joint may be used in smaller lines of minor importance or where temperature variations are slight. It is advisable to break joints between floor and sides of a canal or ditch as shown in Figure *a*. Spacing of joints depends upon local conditions and may vary from 25 to 60 feet.

Thickness of Concrete Linings

It is not possible to specify a uniform thickness for linings of canals excavated in natural soil. Thickness depends largely upon the nature of the soil through which the canal passes, and the range of temperature variation.

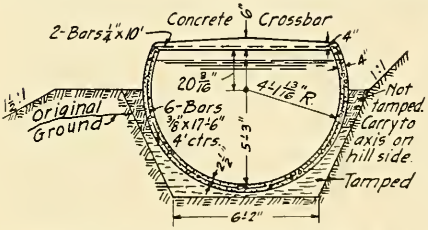


Cross section of concrete-lined channel of the Los Angeles Aqueduct, California.

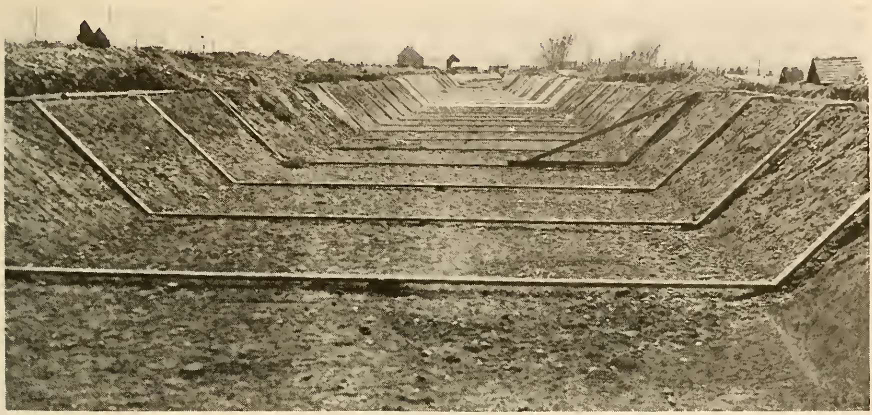


Concrete-lined canal section, Medina Valley Irrigation Co., San Antonio, Texas.

Four inches is considered the minimum thickness of concrete lining that can be safely used for an irrigation canal. It is true that some canals have been lined with concrete of less thickness but these examples were generally in climates subject to very slight temperature changes and the canals were built in stable soils. The chance for cracking in the lining due to settlement of the supporting soil or to other unforeseen conditions justifies the minimum thickness of four inches. Under certain conditions this thickness must be increased, and reinforcement with steel is often required.



Cross section of precast unit for concrete lining Tieton Main Canal, U. S. Reclamation Service, Yakima Project, Wash.

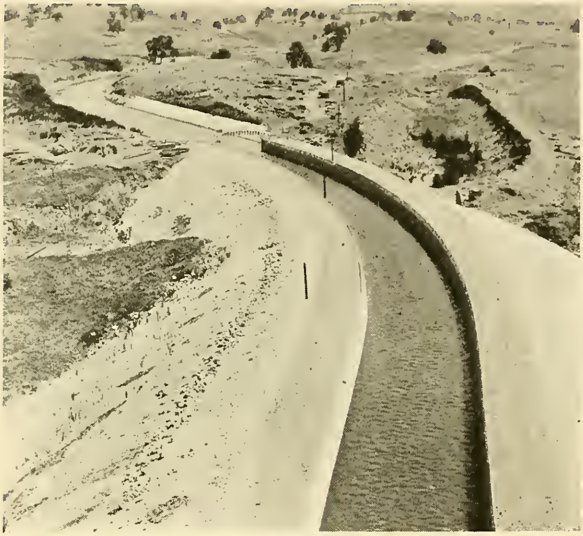


Davis and Weber Counties Irrigation Canal, Utah. The bottom is 21 feet wide, excavation has been completed and the sections prepared to receive the concrete lining.

Velocity of Water in Concrete-Lined Canals

Canals should be so laid out as to obtain uniform velocity of flow and so that water will reach the irrigated district at sufficient elevation to insure even, economical distribution. A high velocity of water in a concrete-lined canal entails extra expense at the turnouts and the walls must be built high to take care of pulsation or wave action induced by rapid flow. Where topographical conditions make a steep grade necessary, a concrete lining is a positive insurance against erosion. According to statements of the U. S. Reclamation Service, there are a number of concrete-lined canals that convey water at velocities exceeding 20 feet per second. In these canals a thin film of green moss usually forms on the concrete—conclusive proof that there is no scouring action. A velocity of 10 feet per second is the maximum rate that should be permitted under ordinary conditions.

Concrete lining in place, Davis and Weber Counties Irrigation Canal, Utah. This canal is 4½ feet deep. Lining is from four to six inches thick.



Concrete-lined canal carried on a deep fill over bed of Delaney Lake, Turlock Irrigation District, Turlock, Calif.

Sharp curves should be avoided when locating canals, as they not only reduce velocity of flow but require special construction for superelevating the outer side of curves when the water flows at high velocity. On the Tieton main canal, Yakima project, Washington, with water flowing at the rate of nine feet per second around curves having a radius of 58 feet, superelevation amounted to one per cent of the width.

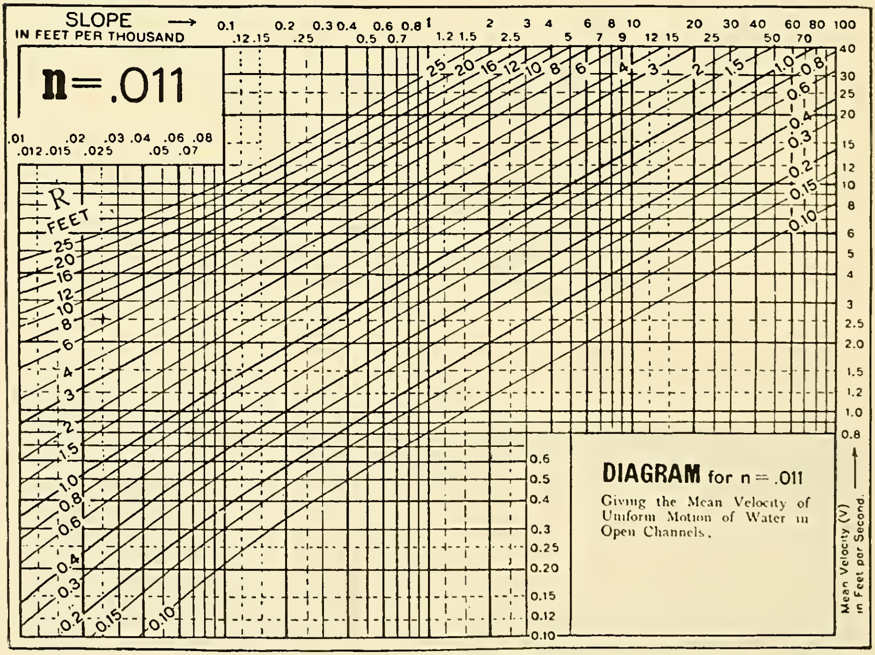


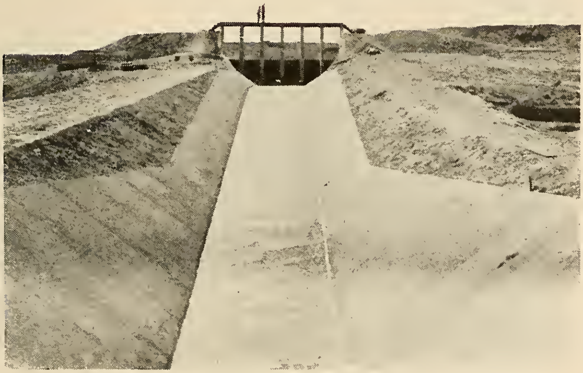
Diagram of mean velocity of flow of water in open channels. By Irving P. Church, C. E., Professor of Applied Mechanics and Hydraulics, College of Civil Engineering, Cornell University. Reproduced by special permission of John Wiley and Sons, New York.

Basin at power drop No. 2, U. S. Reclamation Service, Wapato Project, Yakima County, Washington. Records of the Reclamation Service show that concrete linings are not injured by water velocity exceeding 20 feet per second.

The durability of concrete lining depends not only on good design and construction, but also on the conditions of use to which it is subjected. Damage may come from roots of trees and from storm water during heavy rainfall. Trees should not be allowed to grow near the banks of a concrete-lined canal because eventually the roots are almost certain to heave the concrete, even though it is thoroughly reinforced. Provision should also be made to by-pass storm water from cloudbursts or heavy rains as sudden floods coming from outside sources may raise the water in the canal to such a height as to endanger its safety by washing away the earth backfilling.

Concrete Pipe for Economical Distribution

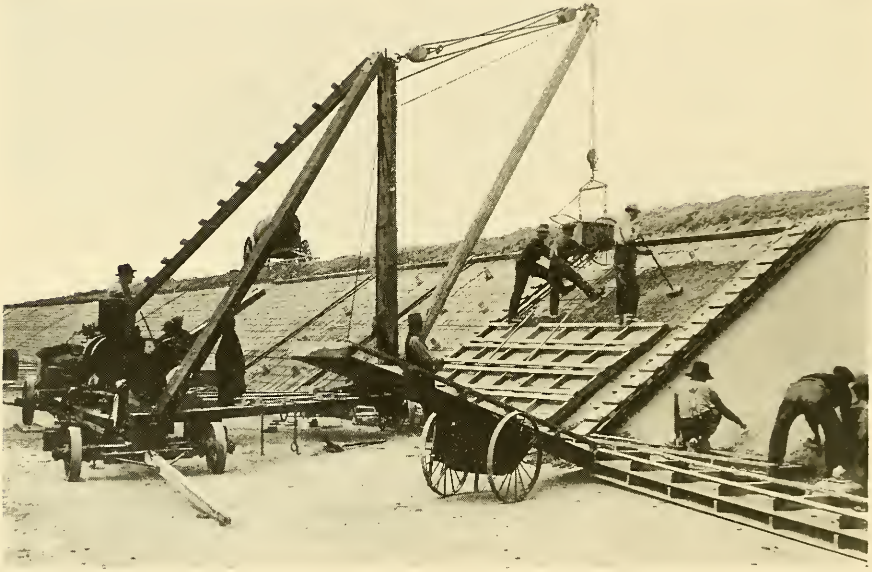
The advantages of concreting the main canals and laterals apply equally to the small distributing channels. This is usually accomplished by the use of concrete pipe, as the lines can be buried to a sufficient depth so that they offer no obstruction to cultivation and besides are able to withstand pressure so as to facilitate economical distribution of water to convenient points in the cultivated area.



Power drop No. 2, Wapato Project, Yakima County, Washington. Concrete linings prove their value under severe conditions.

An experience covering a period of over a quarter of a century on the Pacific Coast, and more especially in

California, has demonstrated that large quantities of water can be saved by the substitution of concrete pipe for open earth ditches. The results of a large number of measurements made by the Irrigation Division of the Bureau of Public Roads, U. S. Department of Agriculture, show that the transmission losses in earthen channels vary from 10 to 60 per cent. and average fully 35 per cent of the quantity of water admitted through the intake. When concrete pipes are substituted for earthen channels, the loss of water in transmission is usually negligible.



Placing concrete linings in the New York Canal, U. S. Reclamation Service, Boise, Idaho. This canal carries the flood water of the Boise River for a distance of 45 miles and supplies water for the irrigation of seventy thousand acres of land.

The use of concrete pipe for the carriage of water and of concrete pipe systems for its distribution to farmers, not only prevents loss of water but affords better facilities for its control, distribution and delivery. Irrigating land by means of open channels in earth is a laborious and unpleasant task, wasteful of water, time and effort. It can be rendered comparatively easy and pleasant if the proper equipment is provided in the form of concrete pipe, with proper gates, turnouts and other fixtures. The interest on the cost of such betterments for highly profitable crops is more than likely to be amply compensated for by the saving of water and labor and by the increased productiveness resulting from a more uniform moistening of the soil.

COPIES of the following publications of the U. S. Department of Agriculture may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at prices indicated.

Bulletin No. 126—"Concrete Linings as Applied to Irrigation Canals," contains useful tables, diagrams and photographs which emphasize the advantages of concrete for canal lining. (10 cents)

Bulletin No. 190—"The Drainage of Irrigated Land." Irrigated land may become waterlogged and impregnated with harmful mineral salts; more than 10 per cent of the entire area that has been irrigated for any considerable period may become absolutely unproductive or useful only for less valuable crops or poor pasture. The practicability of reclaiming waterlogged lands by drainage is demonstrated in this bulletin and methods are described by which the work can be done effectively and economically. (10 cents)

Bulletin No. 906—"The Use of Concrete Pipe in Irrigation." In recent years irrigated land has doubled its original valuation. This has placed a premium on water. The use of concrete pipe for distributing water not only prevents losses but affords excellent facilities for its control and delivery. The bulletin was written to give farmers and orchardists information concerning concrete pipe systems with practical suggestions to help them obtain good results. (20 cents)

30
440
240

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These departments are constantly in touch with the extensive researches being made by the Structural Materials Research Laboratory, operated jointly with the Lewis Institute, Chicago. Their recommendations are based on the most advanced information obtainable.

Educational booklets and pamphlets fully illustrating and describing the important uses of concrete await your request.

We are at your service. Consult us freely.

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AMHERST, MASS.

CONCRETE GRAIN TANKS

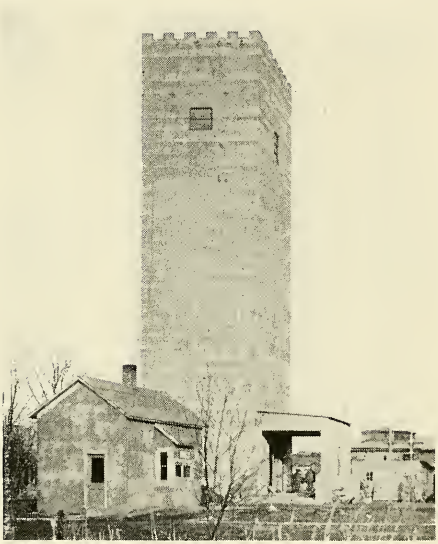
Published by
PORTLAND CEMENT ASSOCIATION

Concrete Grain Tanks

POPULARITY OF CONCRETE BINS

The many well-known advantages of concrete for grain bins and grain elevators have made it the most popular material used for such structures. Every terminal elevator of 100,000 bushels capacity or more built in the past six years is of concrete.

The advantages which have led to the selection of concrete for large elevators make it equally desirable for grain tanks and bins of small and medium size and in the past few years hundreds of such structures have been built throughout the grain-growing states.



Concrete Grain Elevator of the Farmers' Elevator Co., at Homer, Ill. Capacity 20,000 Bushels

CAREFUL PRELIMINARY STUDY NECESSARY IN PLANNING GRAIN STORAGE

In planning a grain bin or elevator the owner will almost invariably select the best available type of machinery, often disregarding first cost to give preference to the most efficient and durable equipment. The same forethought should be displayed in considering the material used in the construction of the building in which the machinery is to be installed and expensive grain stored. Concrete bins and elevators are proof against fire, rust, rot and the depredation of rats and mice.

FIRE HAZARDS IN MILLING INDUSTRIES

Grain elevators, flour and cereal mills have fire hazards peculiar to themselves in addition to those which they have in common with other structures. Explosions are frequent in flour mills owing to the highly explosive dust resulting from handling and milling grain. Disasters of this kind often cause loss of life as well as property. Choked elevator legs are frequent causes of fire, and spontaneous combustion of grain in combustible bins results in loss of structure as well as contents. In addition, grain elevators are usually located on a railroad right-of-way and are subject to danger of fire caused from locomotive sparks. About 14 per cent of the elevator fires recently reported by a

Elevator and Concrete Bins for Storing Shelled Popcorn on an Iowa Farm

large fire insurance company resulted from this cause. The only way to guard against these hazards is to build as nearly fireproof as possible. Concrete bins and elevators not only save money on insurance, but also give protection against loss of business which insurance cannot repay.

LOW INSURANCE RATES

One of the desirable features of the concrete elevator is the saving in the cost of insurance. Fire insurance companies recognize the safety secured by concrete elevators and therefore give them marked preference in insurance rates.

The average insurance rate for wood elevators and contents is $2 per $100. On concrete elevators and contents the base rate is about 27 cents, and if the elevator is correctly designed this figure need not be exceeded. Many elevator men do not consider it necessary to carry insurance on either a concrete elevator or its contents, but since there is always danger of fire from the power plant and from spontaneous combustion, some insurance is desirable.

In order to demonstrate the saving which can be made each year on a concrete elevator as compared to one of ironclad wood construction, the following figures are presented. Owing to the recent shifting of price levels the cost of both types is now practically identical. It is manifestly impossible to assume figures that will fit in all cases, but as a general average the figures given are fair:

Iron-clad wood elevator, 40,000 bushels	$30,000
Concrete elevator, 40,000 bushels	30,000

In the following calculation the insurance on one-third of the value of the concrete elevator is included to cover damage to machinery and structure:

WOOD ELEVATOR

Insurance on building, 80% of value, at $2	$480.00	
Contents—30,000 bushels grain at $1.25 per bushel, for 5 months, at $2 per year	312.50	
		$792.50

CONCRETE ELEVATOR

Insurance on building, 33⅓% of value, at 27 cents	$ 27.00	
Contents—30,000 bushels grain at $1.25 per bushel, for 5 months, at 27 cents per year	42.25	
		69.25

Annual Saving of Concrete Over Wood	$723.25

FIRE PROTECTION

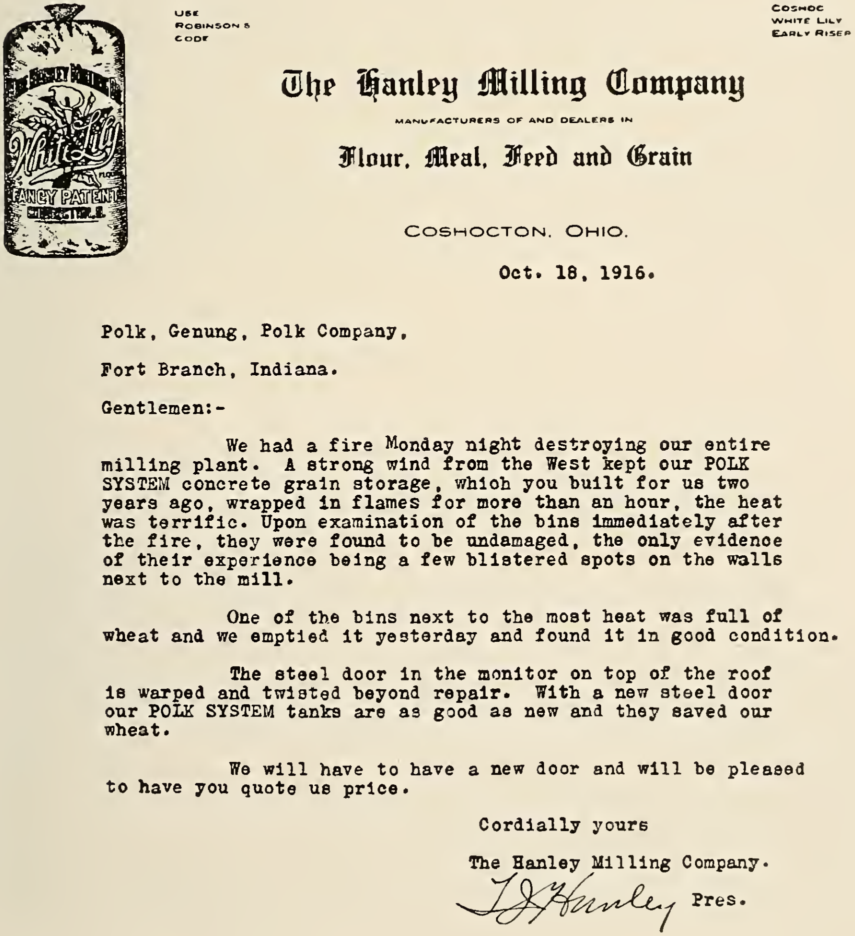
Concrete gives fire protection aside from the saving in insurance. Insurance can repay only part of the loss of building and contents and can never cover loss of business resulting from fire. No matter what precautions are taken, the owner of a wood elevator can never go home at night with any assurance that the structure will be standing the next morning. Security can be felt only when fireproof materials are used and if there were no other reasons for using concrete, this fact alone should cause the prospective builder to decide in its favor.

Concrete Grain Storage Tanks of Horton Bros., Garrett, Ill. Total Capacity 40,000 Bushels

BEFORE AND AFTER THE FIRE

Four years ago the Hanley Milling Co., of Coshocton, Ohio, built a battery of four concrete grain storage tanks. They wanted a rat-proof, fireproof, permanent structure in which to store grain for their milling operations.

On Monday, October 16, 1916, fire destroyed the Hanley Milling Company's mill building, which was of frame construction. Below is a reproduction of a letter which tells the story.


White Lily
Flour
Fancy Patent

Use
Robinson's
Code

Coshoc
White Lily
Early Riser

The Hanley Milling Company

MANUFACTURERS OF AND DEALERS IN

Flour, Meal, Feed and Grain

COSHOCTON, OHIO.

Oct. 18, 1916.

Polk, Genung, Polk Company,

Fort Branch, Indiana.

Gentlemen:-

We had a fire Monday night destroying our entire milling plant. A strong wind from the West kept our POLK SYSTEM concrete grain storage, which you built for us two years ago, wrapped in flames for more than an hour, the heat was terrific. Upon examination of the bins immediately after the fire, they were found to be undamaged, the only evidence of their experience being a few blistered spots on the walls next to the mill.

One of the bins next to the most heat was full of wheat and we emptied it yesterday and found it in good condition.

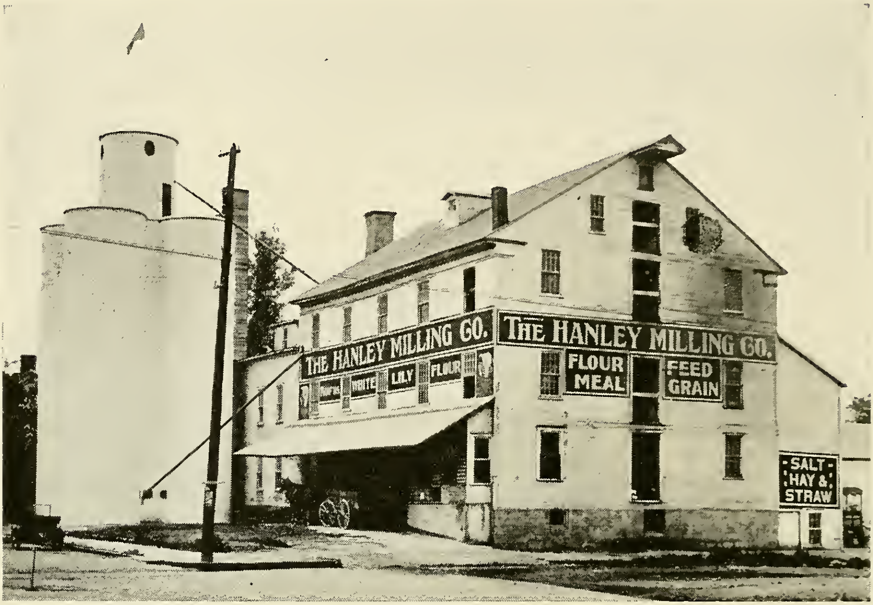
The steel door in the monitor on top of the roof is warped and twisted beyond repair. With a new steel door our POLK SYSTEM tanks are as good as new and they saved our wheat.

We will have to have a new door and will be pleased to have you quote us price.

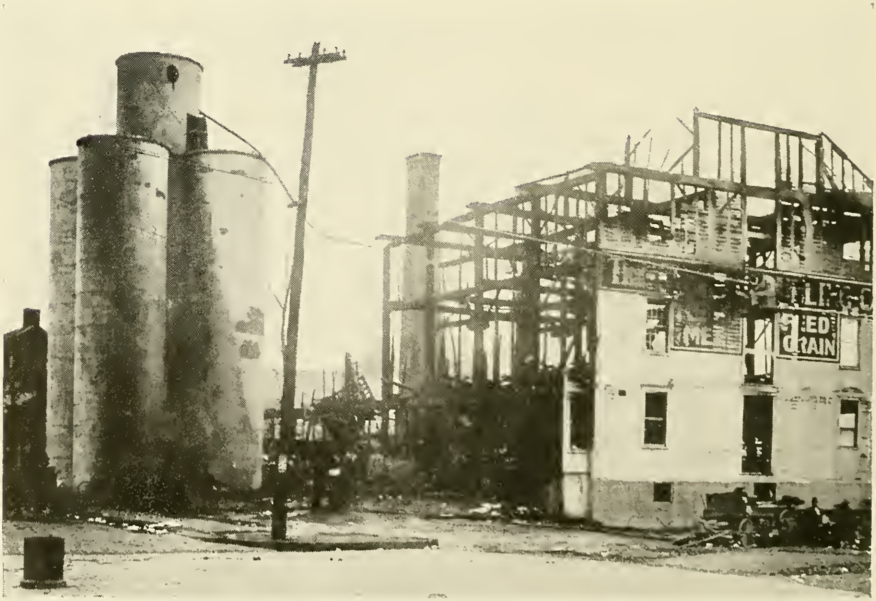
Cordially yours

The Hanley Milling Company.

T J Hanley Pres.

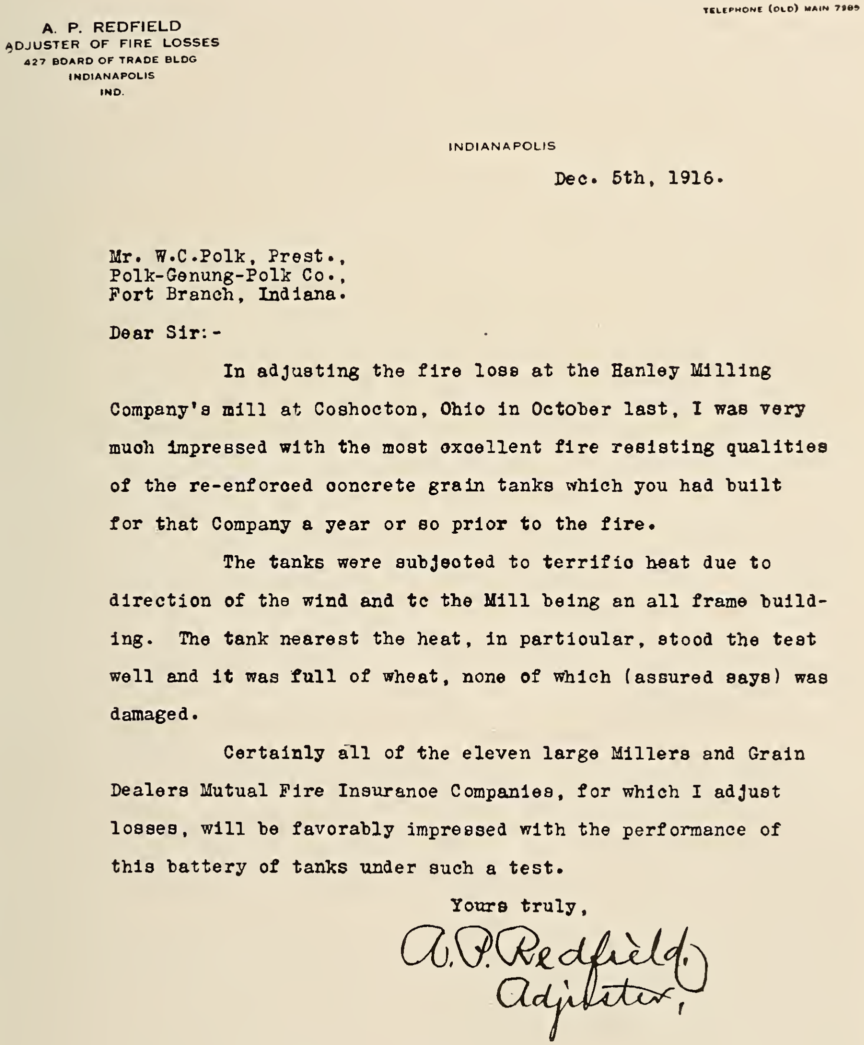


Mill and Concrete Grain Bins of the Hanley Milling Co. Before the Fire



View of the Hanley Milling Co.'s Plant from Practically the Same Point as Above, After the Fire. Note How the Concrete Bins Resisted the Fire

Confirmation of the statements in Mr. Hanley's letter is hardly needed. If it were, however, it can be found in the letter by A. P. Redfield, who adjusted the fire loss of the Hanley Milling Co.



A. P. REDFIELD
ADJUSTER OF FIRE LOSSES
427 BOARD OF TRADE BLDG
INDIANAPOLIS
IND.

TELEPHONE (OLD) MAIN 7989

INDIANAPOLIS

Dec. 5th, 1916.

Mr. W.C.Polk, Prest.,
Polk-Genung-Polk Co.,
Fort Branch, Indiana.

Dear Sir:-

In adjusting the fire loss at the Hanley Milling Company's mill at Coshocton, Ohio in October last, I was very much impressed with the most excellent fire resisting qualities of the re-enforced concrete grain tanks which you had built for that Company a year or so prior to the fire.

The tanks were subjected to terrific heat due to direction of the wind and to the Mill being an all frame building. The tank nearest the heat, in particular, stood the test well and it was full of wheat, none of which (assured says) was damaged.

Certainly all of the eleven large Millers and Grain Dealers Mutual Fire Insurance Companies, for which I adjust losses, will be favorably impressed with the performance of this battery of tanks under such a test.

Yours truly,

A.P. Redfield,
Adjuster,

These letters tell briefly and concisely what may be expected in the way of protection against fire, afforded by concrete construction.

DEPRECIATION

Insurance companies consider the life of a timber structure about 25 years, which means a 4 per cent depreciation charge annually. Certainly it will last no longer than 25 years without expensive repairs. Depreciation of a concrete elevator can scarcely be more than 1 or 1½ per cent. On a 40,000-bushel wood elevator the depreciation will amount to $1,200 annually; on a concrete elevator of the same size, only $450. The difference will pay the insurance on the concrete structure and its contents and leave a balance of $680.75 yearly.

GRAIN LOSSES FROM INSECTS AND RODENTS

Concrete has another important advantage. Contents of grain bins and elevators cannot be destroyed by rats and mice. The loss resulting from the depredations of these rodents has been estimated as running into the millions yearly. Whatever it is, this loss will be prevented by building of concrete. In that way concrete bins and elevators will contribute to reducing the high cost of living.

The nature and extent of damage resulting from insects in stored grain is reported in Farmers Bulletin No. 45, published by the United States Department of Agriculture, Washington, D. C. The following is quoted from that bulletin:

Concrete Grain Tanks of the Colorado Milling & Elevator Co., Cotterel, Idaho.
Capacity 27,000 Bushels

"Of the insect injury to stored grain it has been estimated of Texas alone that there is an annual loss of over a million dollars, and that nearly 50 per cent of the corn of that state is annually destroyed by weevils and rats. The loss from granary insects to the corn crop in Alabama in 1893 was estimated at $1,671,382, or about 10 per cent.

"There are seven other states subject to the same atmospheric and other influences as Alabama, and producing in the aggregate a somewhat larger average yield of corn. Estimating the annual loss in the same proportions, we would have for these eight Southern states, viz.: South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas and Arkansas, a total of nearly $20,000,000. This is for corn alone and does not take into consideration wheat and other grains or mill products."

Concrete being rotproof cannot breed nor harbor insects. If by chance infected grain is stored in a concrete bin, thorough fumigation or sterilizing can be done by fire or germicides without in any way harming the structure. Insects are generally destroyed by fumigation with bisulphide of carbon. Concrete bins being airtight prevent the loss of any of the fumes and make the operation of fumigation most effective.

CONCRETE BINS ARE DRY

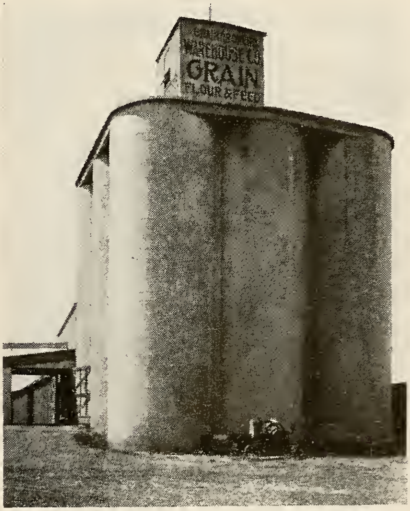
Only good workmanship is necessary to insure a damp-proof concrete bin. Long experience with concrete grain elevators has shown that they are perfectly dry and that grain stored in them keeps in perfect condition. Damp grain is sometimes placed in concrete bins. It can sweat in the bins only when stored in such condition; but a drying apparatus can be installed for blowing dry air through the bin and its contents. Cement mills store their stocks of cement in concrete bins. They would not do so unless the bins were proof against moisture, and portland cement is far more susceptible to moisture than is grain.

CONCRETE BOOTS ARE WATERTIGHT

Below or at the bottom of each concrete grain elevator is a pit or boot which serves for some of the mechanism operating the bucket elevator. It is necessary that this boot be watertight, and if constructed of concrete replacement is unnecessary. Concrete boots are permanent as well as watertight.

A firm of engineers in Illinois says:

> "We have built 5-inch thick hopper floors six to eight feet below ground and have had no difficulty with grain getting damp. We have placed concrete elevator bins eight feet below water and they are watertight."



Concrete Elevator of the Grain Growers' Warehouse Co., Wilbur, Wash.

CIRCULAR BINS OFTEN MOST ECONOMICAL

At one time the expense of constructing forms for circular concrete construction no doubt influenced many grain dealers and shippers to build of less durable materials, but the commercial silo forms and other types of forms adapted to circular concrete construction have been so perfected that now the accepted shape of concrete grain bins or tanks is round. They are usually erected in groups or batteries of four or more tanks, the space enclosed by the joining of the four tank walls being used to house the operating and elevating machinery.

There is a striking similarity between the modern concrete silo and the modern concrete grain storage tank or elevator. Many contractors are now equipped for and specializing in the construction of circular grain tanks. In general, cylindrical bins are somewhat cheaper than rectangular ones of like capacity.

VALUE OF CONCRETE STORAGE FACILITIES

No grain dealer can afford to take the risk of doing business without the protection of concrete grain storage bins or elevators. The modern farmer is learning that he also can profit from storing his grain in concrete construction. Market conditions are not always best at harvest time. Crops sold then may not yield the greatest possible returns because every one is inclined to unload a large part of his farm produce as soon as harvested. This gluts the market and forces down prices. With suitable concrete storage bins the farmer can hold his grain for several months or until a favorable turn of the market and can often realize a margin of profit through such holding that otherwise would have been lost. The grain dealer has such storage facilities and usually profits thereby.

In many communities farmers are now joining in cooperative movements to build community elevators so that their grain may

Concrete Grain Tanks of the Tamalina Milling Co., San Antonio, Tex.

be held until market conditions are most favorable. They are also building of concrete because of the protection afforded against loss by rats and fire.

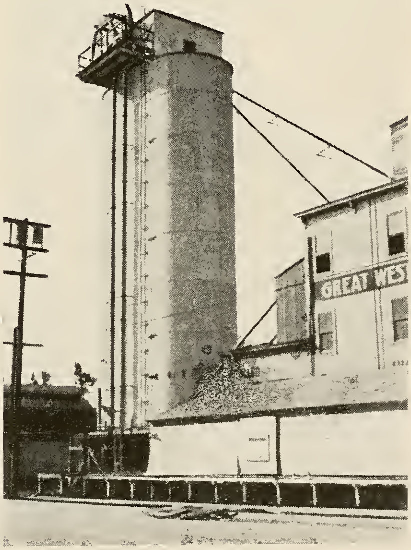
ECONOMY OF HANDLING GRAIN IN BULK

At a convention of the Grain Growers Association in Spokane, Wash., May 6, 1916, figures were presented to show the comparative cost of handling grain from field to market in sacks and in bulk. Various items of cost of handling in sacks totaled 26¾ cents per bushel. Similar items involving handling in bulk totaled 21½ cents per bushel. Crediting return of sacks at 3 cents per bushel, there was 2½ cents per bushel net saving in favor of bulk handling. The convention made the following declaration:

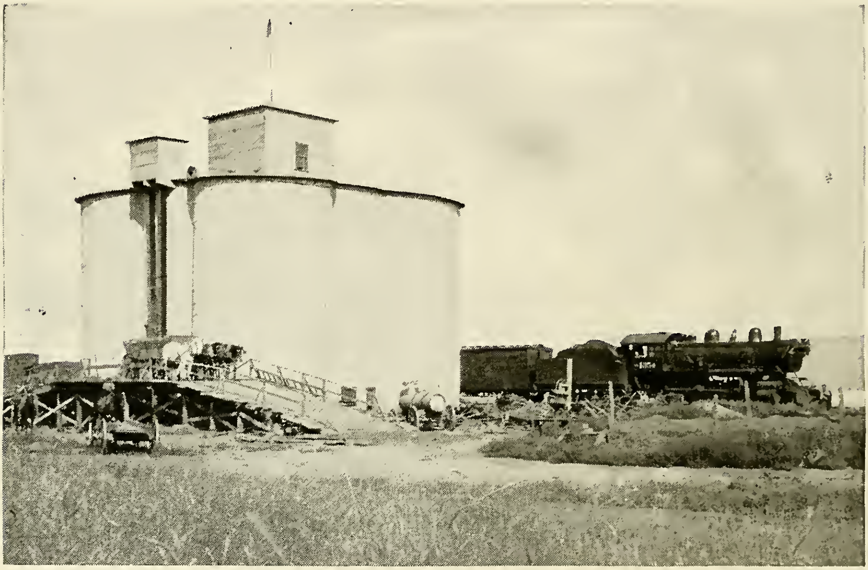
> "We believe that a successful system of handling grain in bulk depends upon the individual farmer providing his own storage on the farm either by bins, granaries or farm elevators where grain may be held until sold."

The illustration on the next page shows a battery of four grain bins owned by a Washington farmer. They were built in 1914, have a capacity of 45,000 bushels, and cost, including machinery and equipment, $14,000. This is about 37 cents per bushel of capacity.

The four tanks are each 20 feet in diameter and 56 feet high. They are set on a circle 50 feet in diameter and are connected by four arched walls. A large interior bin is thus secured for the housing of the elevating and cleaning equipment. The elevating machinery is enclosed in a circular shaft 5 feet in diameter. A smut machine and an automatic weighing device for outgoing grain are part of the plant equipment. Grain is brought in bulk from the fields and dumped into a receiving hopper, from where it goes to the cleaning machine and finally to the bins.



Concrete Grain Bins at the Plant of the Great Western Milling Co., Los Angeles, Cal.



Concrete Grain Elevator and Bins on the Farm of a Washington Farmer. This Plant Has Shown a Net Yearly Saving to the Owner of $1,910

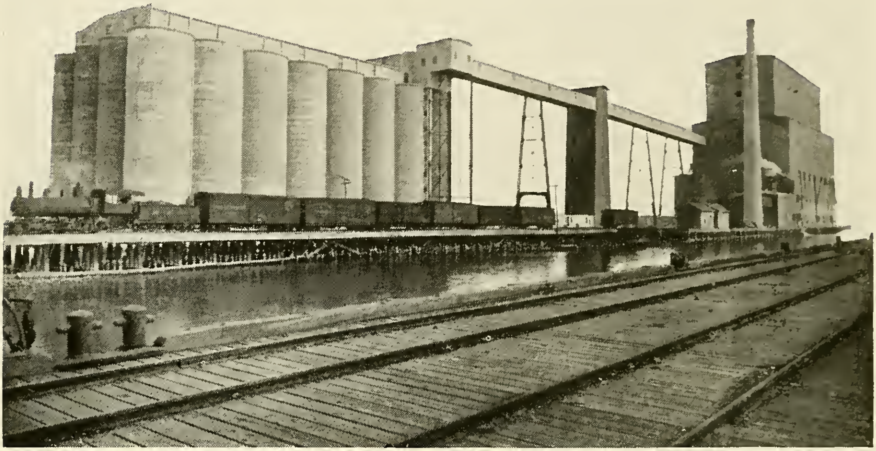
It has been the custom in the Pacific coast states to sack most of the grain. This procedure entails a considerable expense for sacks, twine, labor in handling and storage charges. These items are becoming more costly day by day and the farmer who is equipped to handle grain in bulk is realizing a larger percentage of profits yearly. Aside from securing a net yearly saving, the farmer equipped with concrete grain tanks has the satisfaction of knowing he is independent of usual conditions. The situation is at all times under his control. He has no insurance or storage charges to pay, can keep his grain dry, protected from fire, rodents and insects, can sell it when so inclined and is entirely free from the unfavorable conditions confronting many who must haul their grain to the nearest flat warehouse.

BUSINESS INSURANCE

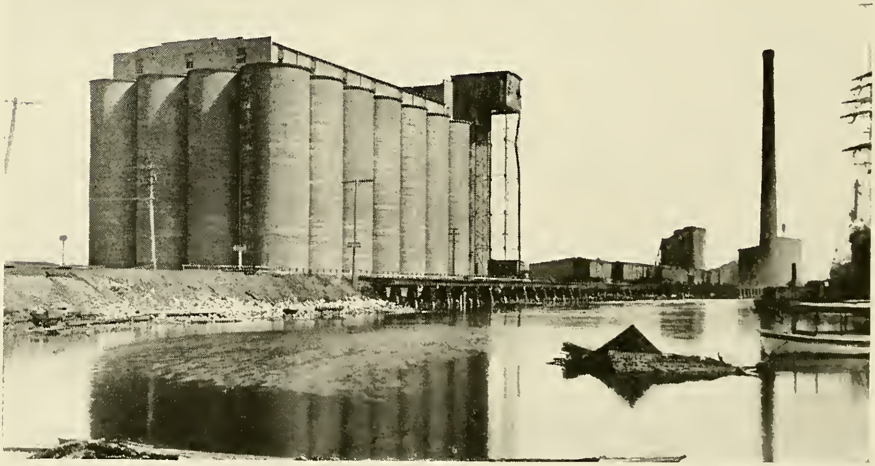
When an elevator is destroyed by fire a certain amount of business is bound to be lost with it. Customers will be obliged to sell their grain to a competitor and if he is a good business man, many of your former customers will continue to patronize him even after you have rebuilt. A concrete elevator attracts business. It is only natural for farmers to haul their products to the best equipped elevator.

Concrete Grain Tanks of Central Mills, Dixon, Ill. Tanks Like These Insure Their Owner Against Losses From Fire, Rodents, Insects and Interruptions to Business

The Interior Terminal Elevator of the Canadian Government at Calgary, Alberta



Elevator and Concrete Grain Bins of the Pennsylvania Railroad at Baltimore

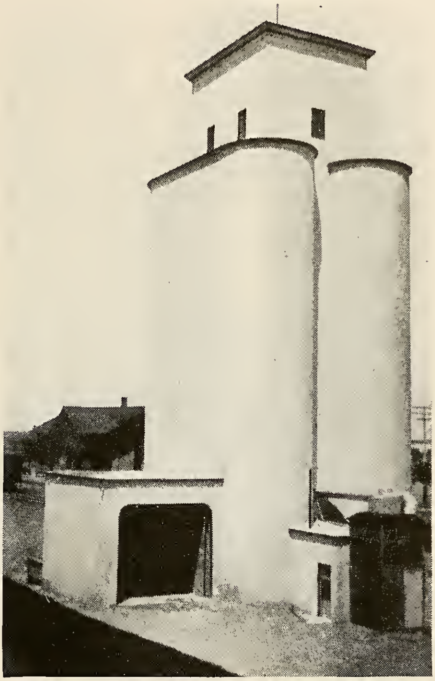


The Same Plant as Shown Above with Concrete Construction Intact after the Fire

CONCRETE TANKS GOING UP EVERYWHERE IN THE GRAIN-GROWING STATES

Throughout all of the grain-growing states farmers are putting up similar tanks in which to store all classes of grain. The cost of these tanks is dependent upon the cost of local materials and labor and the efficiency of labor. Construction of small concrete bins may be undertaken by the farmer and his own men at times when there is not much work to be done on the farm, but it is usually best to engage a competent, responsible contractor for the job because of his equipment and experience.

For commercial elevators and for storage capacity exceeding 30,000 bushels, a competent designer should prepare the plans and specifications and the work should be done by experienced contractors.

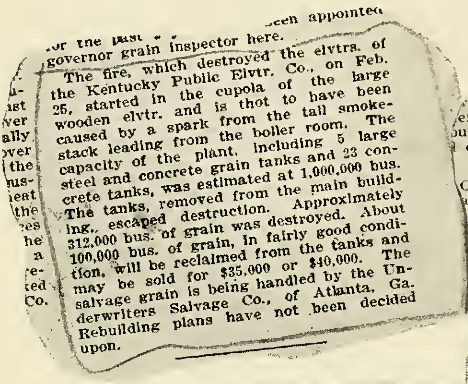


Concrete Grain Elevator of the Hardman Lumber Co., Wakeeney, Kans. Capacity 50,000 Bushels

LET US HELP YOU WITH YOUR GRAIN STORAGE PROBLEMS

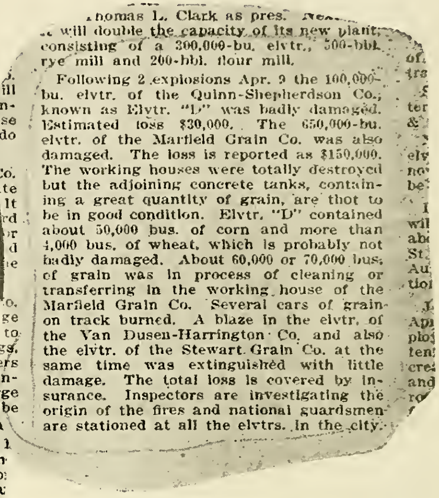
The Portland Cement Association, 111 West Washington Street, Chicago, can give information on the thickness of walls and the amount of reinforcement to use and simple instructions as to the proper proportioning, mixing and placing of concrete. It will also be glad to give you names and addresses of engineers and contractors competent to design and construct grain bins and elevators, and to confer and advise with any intending builders who are interested in or propose to build such structures.

BELOW are a few reasons why you should own a fireproof, concrete elevator.



governor grain inspector here.

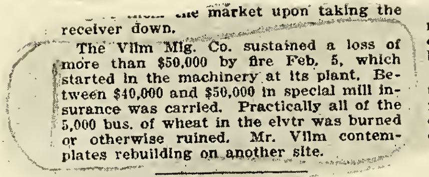
The fire, which destroyed the elvtrs. of the Kentucky Public Elvtr. Co., on Feb. 25, started in the cupola of the large wooden elvtr. and is thot to have been caused by a spark from the tall smokestack leading from the boiler room. The capacity of the plant, including 5 large steel and concrete grain tanks and 23 concrete tanks, was estimated at 1,000,000 bus. The tanks, removed from the main building, escaped destruction. Approximately 312,000 bus. of grain was destroyed. About 100,000 bus. of grain, in fairly good condition, will be reclaimed from the tanks and may be sold for $35,000 or $40,000. The salvage grain is being handled by the Underwriters Salvage Co., of Atlanta, Ga. Rebuilding plans have not been decided upon.



Thomas L. Clark as pres.

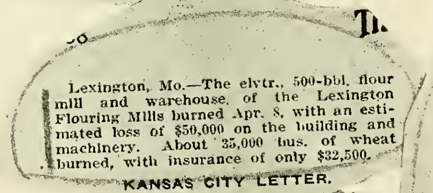
will double the capacity of its new plant, consisting of a 300,000-bu. elvtr., 500-bbl. rye mill and 200-bbl. flour mill.

Following 2 explosions Apr. 9 the 100,000-bu. elvtr. of the Quinn-Shepherdson Co., known as Elvtr. "D" was badly damaged. Estimated loss $30,000. The 650,000-bu. elvtr. of the Marfield Grain Co. was also damaged. The loss is reported as $150,000. The working houses were totally destroyed but the adjoining concrete tanks, containing a great quantity of grain, are thot to be in good condition. Elvtr. "D" contained about 50,000 bus. of corn and more than 4,000 bus. of wheat, which is probably not badly damaged. About 60,000 or 70,000 bus. of grain was in process of cleaning or transferring in the working house of the Marfield Grain Co. Several cars of grain on track burned. A blaze in the elvtr. of the Van Dusen-Harrington Co. and also the elvtr. of the Stewart Grain Co. at the same time was extinguished with little damage. The total loss is covered by insurance. Inspectors are investigating the origin of the fires and national guardsmen are stationed at all the elvtrs. in the city.



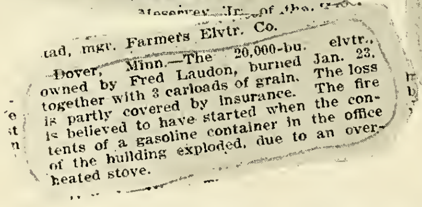
market upon taking the receiver down.

The Vilm Mfg. Co. sustained a loss of more than $50,000 by fire Feb. 5, which started in the machinery at its plant. Between $40,000 and $50,000 in special mill insurance was carried. Practically all of the 5,000 bus. of wheat in the elvtr was burned or otherwise ruined. Mr. Vilm contemplates rebuilding on another site.



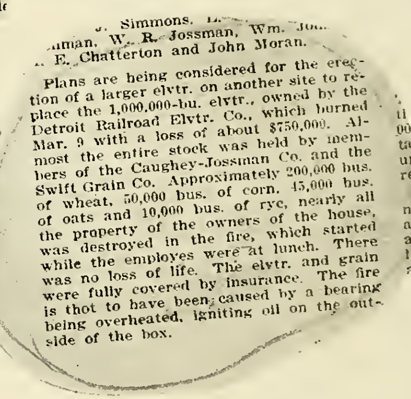
Lexington, Mo.—The elvtr., 500-bbl. flour mill and warehouse, of the Lexington Flouring Mills burned Apr. 8, with an estimated loss of $50,000 on the building and machinery. About 35,000 bus. of wheat burned, with insurance of only $32,500.

KANSAS CITY LETTER.



mgr. Farmers Elvtr. Co.

Dover, Minn.—The 20,000-bu. elvtr., owned by Fred Laudon, burned Jan. 23, together with 3 carloads of grain. The loss is partly covered by insurance. The fire is believed to have started when the contents of a gasoline container in the office of the building exploded, due to an overheated stove.



Simmons,

W. R. Jossman, Wm.

E. Chatterton and John Moran.

Plans are being considered for the erection of a larger elvtr. on another site to replace the 1,000,000-bu. elvtr., owned by the Detroit Railroad Elvtr. Co., which burned Mar. 9 with a loss of about $750,000. Almost the entire stock was held by members of the Caughey-Jossman Co. and the Swift Grain Co. Approximately 200,000 bus. of wheat, 50,000 bus. of corn, 45,000 bus. of oats and 10,000 bus. of rye, nearly all the property of the owners of the house, was destroyed in the fire, which started while the employes were at lunch. There was no loss of life. The elvtr. and grain were fully covered by insurance. The fire is thot to have been caused by a bearing being overheated, igniting oil on the outside of the box.

(*Clippings from The Grain Dealers' Journal, Chicago*)

Portland Cement Association

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San Francisco
Seattle
St. Louis
Washington

P83 no. 8 Massachusetts Agricultural College,
AMHERST, MASS.

Concrete Grapevine Posts

Concrete posts are rapidly replacing wood posts in vineyards because of their many superior qualities. Satisfactory posts can be made by a man who has had no previous experience if he is careful to follow the directions given in this booklet.

Published by

Portland Cement Association

Concrete Grapevine Posts

CONCRETE posts are rapidly replacing wood posts in vineyards because of their many superior qualities. Concrete posts will not rot and are not injured by borers or by fungus growths. There is no expense of replacing as in the case of posts that decay. Their uniformity in size and shape makes them easy to set and line up, and a vineyard with concrete posts presents an attractive appearance, which enhances the value of the property. A supply of these concrete posts can be made during the winter or at times when work is slack, thus turning time otherwise idle to profitable account.

Concrete posts for the vineyard are rotproof and unaffected by borers or fungus. They are easily made, and a supply can be accumulated during the winter months when other work has slackened.

Making posts of concrete is a comparatively easy operation. Even a man who has had no previous experience can make a satisfactory concrete post if he is careful to follow closely the directions given in this booklet.

Concrete posts are made in a number of different shapes. The most common types are illustrated on page 4. When home-made molds or forms are used, concrete posts having a square or nearly square cross-section will generally be found the easiest to make. Posts having a triangular, round, half round or "T" shaped section are usually made in metal molds. A list of manufacturers of metal molds is given on page 7.

HOME-MADE MOLDS

An easily constructed home-made form in which six posts can be cast at one time is shown in the drawing. If a good level floor is available it will not be necessary to build a platform. Lumber used in constructing molds should be sound, straight grained and finished smooth on the sides that will come in contact with the concrete. The pallets, side and end pieces are of two-inch material. To prevent the boards from warping or sticking to concrete, they should be soaked or painted with boiled linseed oil, thinned with kerosene. Machine oil or the oil removed from the automobile crank case may be used in place of linseed oil.

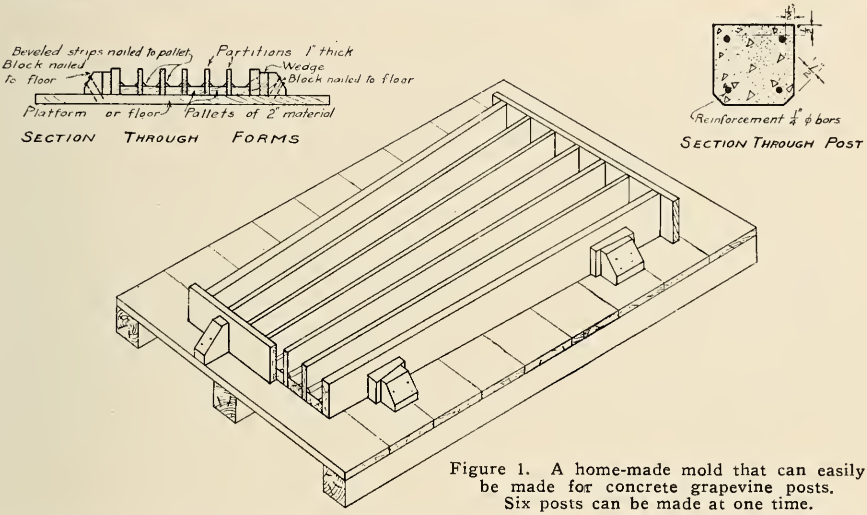


Figure 1. A home-made mold that can easily be made for concrete grapevine posts. Six posts can be made at one time.

The usual length of posts is from 7 to 8 feet. A strong, neat appearing post will be obtained by making the base 4 by 5 inches and tapering the post to 4 by 3 inches at the top. Then 2 by 4's can be used for the pallets. Small triangular strips are tacked to the pallets to chamfer two edges of the post.

CONCRETE MIXTURES

A 1:2:2 or a 1:2:3 mixture of concrete is recommended for grapevine posts. By a 1:2:3 mixture is meant one part portland cement, two parts sand and three parts pebbles or crushed rock; if the latter is not available, a mixture of one part cement to three parts sand may be used. Do not use gravel, or the natural mixture of sand and pebbles as it comes from the pit, unless it is first screened to separate the sand and pebbles in order that they may be accurately proportioned. A screen having openings one-quarter inch square is used for the purpose. The material which will go through this screen is known as sand or fine aggregate, while the material which will not pass through is pebbles or coarse aggregate. Both sand and pebbles should be clean, tough and variable in size from fine to coarse, or as concrete workers say, it should be well graded. In no case should any of the pebbles be larger than three-fourths inch in size; in posts with thin sections the maximum allowable size of pebbles is one-half inch.

Cement, sand and pebbles should be mixed together thoroughly. Machine mixing is to be preferred as in this way thorough mixing is easier to obtain and all batches will be uniform, however, first-class concrete can be mixed by hand. Which ever way mixing is done, it should be continued until every pebble is completely coated with a thoroughly mixed mortar of sand and cement. Clean water such as is fit for drinking should be added to make the mixture of a quaky or jelly-like consistency.

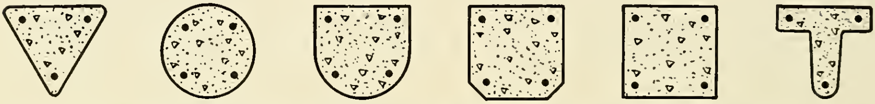


Figure 2. The above illustration shows a cross-section of the most common types of concrete posts. The square, or nearly square are the most easily made in home-made molds. The black dots show how the reinforcement should be placed.

REINFORCEMENT

Reinforcing a concrete post deserves special attention. The round black spots shown in the illustration of cross-sections on this page represent the proper location of reinforcing rods. The rods are located near each corner where the greatest tensile stresses occur and from one-half to three-fourths inch from the surface in order that moisture will not penetrate to them, causing the steel to rust. Reinforcement in the center of the post is useless. One-quarter inch round or square steel rods have proved to be most satisfactory for reinforcing concrete grapevine posts.

It is a mistake to think that almost any kind of scrap iron, or even barbed fence wire, will serve for reinforcement. Such wire is often so rusty or dirty that concrete will not stick to it. It is therefore, useless. Wire is also usually purchased in coils and is difficult to straighten so that it will stay in the proper place while depositing concrete. Economy of time and much greater certainty of successful results follow the use of steel rods.

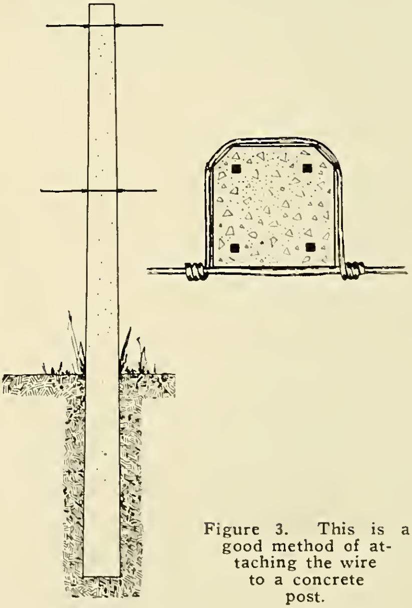


Figure 3. This is a good method of attaching the wire to a concrete post.

PLACING CONCRETE

The thoroughly mixed concrete is first placed about one inch deep in the mold, then two reinforcing rods are pressed into the concrete, one in each corner from one-half to three-quarters of an inch from side and bottom. The mold is then filled with concrete to about one-half inch from the top and the other two reinforcing rods carefully imbedded in it. The mold is then filled to the top, struck off and troweled. As concrete is placed it should be compacted by jarring or tapping the mold and by running the trowel along the form faces and up and down in the concrete. This operation works coarse particles back from surface, remove air bubbles and produces a dense concrete.

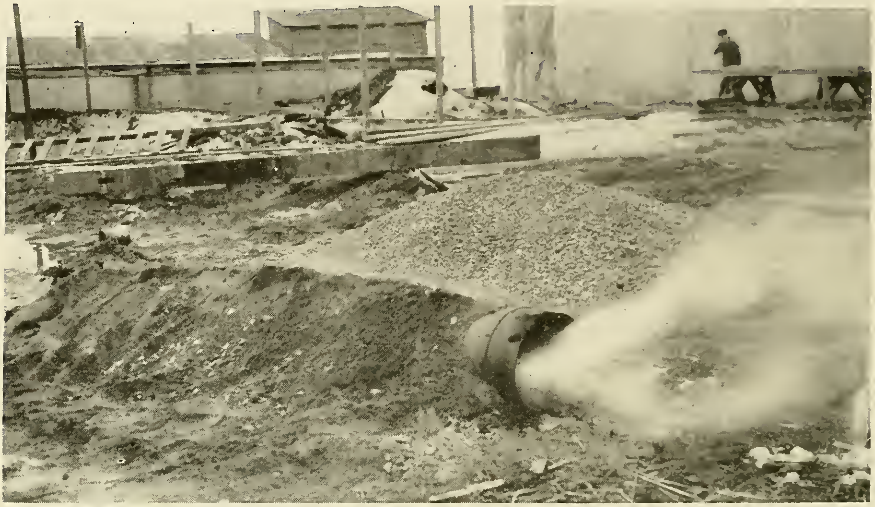
The uniformity in size and shape of concrete posts makes them easy to line up and the attractive appearance enhances the value of the vineyard.

TAKING POSTS OUT OF MOLDS

After the molds have been filled they should remain undisturbed until the concrete has hardened sufficiently to permit removing the posts without damage. In summer 24 hours may be sufficient but in cold weather more time will be required. Be careful not to crack posts when removing them. Forms should be cleaned each time before being refilled. A stiff broom or a wire brush will be found very suitable for the purpose. If made in summer keep the posts in a shady place and out of the wind for a week or ten days after removing from molds so they will harden properly. If shade is not available, a covering of straw or sand, kept moist by sprinkling, will be satisfactory. Posts should be at least 28 days old before being set and it is a good plan to allow them to cure two or three months before being used.

ATTACHING WIRES

Probably the simplest and most practical method of attaching wires is to tie them to the posts by wire loops as shown in Figure 3, on the opposite page. This is easily done and the wire is held tightly against the face of the post.



If posts are made in the winter, sand and pebbles should be heated before the concrete is mixed. A good plan is to pile them over an old metal pipe in which a fire can be built.

MAKING POSTS IN WINTER

Concrete posts for grapevines can be made almost as easily in winter as in summer. All that is necessary is a work room in the barn, granary, basement, or some other place where the temperature will not fall below freezing or where the temperatures can be kept above freezing by means of stoves or heaters. Sand and pebbles should be hauled before pits freeze and stored in a place where they are protected from frost. In case they must be piled outdoors, it is a good scheme to heap them up over a section of chimney or culvert pipe or some other heater so designed that a fire can be built underneath and thaw out any particles that may have been frozen.

A supply of several hundred posts can be made in a surprisingly short time and with very little labor and once made they will give many years of service because they will not decay and are not destroyed by borers.

Concrete posts are cheapest in the end because they are permanent and do not need to be replaced

The water should also be heated if the posts are made during cold weather. The above cut shows a simple method of heating it in a tank.

COMMERCIAL POST MOLDS

If one is considering the manufacture of a considerable quantity of concrete fence posts, purchase of the commercial steel molds and post making tools will be found true economy. The following firms manufacture fence post molds and post making tools and will be glad to send full information about their products upon request.

American Cement Machine Co......	Keokuk, Iowa
D. & A. Post Mold Co.............	Three Rivers, Mich.
Hotchkiss Lock Metal Form Co.....	Binghampton, N. Y.
Ideal Concrete Machinery Co.......	Cincinnati, Ohio
Milwaukee Post Mold Co..........	Milwaukee, Wis.
National Concrete Machinery Co....	Madison, Wis.
Ohio Post Mold Co................	622 Madison Ave., Toledo, O.
Raber & Lang.....................	Kendallville, Ind.
Universal Cement Post Mold Co....	Morristown, Ind.
E. L. Miller Mfg. Co...............	22 W. 33d St., Kansas City, Mo.
Permanent Products Co............	140 S. Dearborn St., Chicago
Concrete Equipment Co...........	Holland, Mich.

Concrete for Permanence

There are many improvements about the farm and home that are better when built with concrete. Here is a partial list:

- Basement Floors
- Benches
- Cellars
- Cisterns
- Clothesline Posts
- Cold Frames
- Culverts
- Dairy Barn Floors
- Driveways
- Feeding Floors
- Fence Posts
- Flower Boxes
- Foundations
- Garages
- Gate Posts
- Hotbeds
- Mangers
- Manure Pits
- Paved Playgrounds
- Porches
- Porch Piers
- Poultry House
- Ratproofing Buildings
- Refuse Burners
- Sand Boxes
- Septic Tanks
- Sheds
- Storage Cellars
- Steps
- Stucco
- Tanks
- Troughs
- Tennis Courts
- Walks
- Weights
- Well Curbs and Covers

Write for free information concerning the use of concrete for any of the above or other improvements in which you are interested.

Portland Cement Association

A National Organization to Improve and Extend the Uses of Concrete

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Denver
Des Moines
Detroit
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Indianapolis
Kansas City
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Salt Lake City
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Seattle
St. Louis
Vancouver, B. C.
Washington, D. C.

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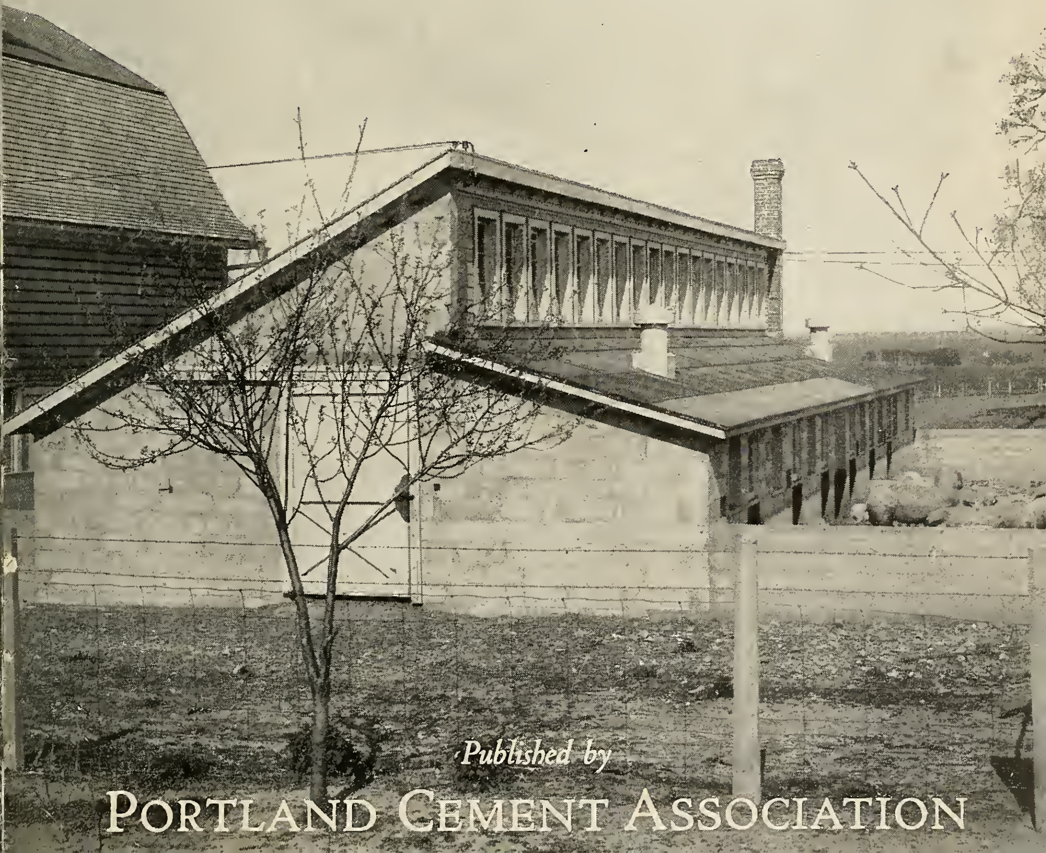
P83

Massachusetts Agricultural College,
AMHERST, MASS.

Concrete on the Hog Farm

oncrete Block Hog House on the
inehurst Farm near Rockford, Ill.



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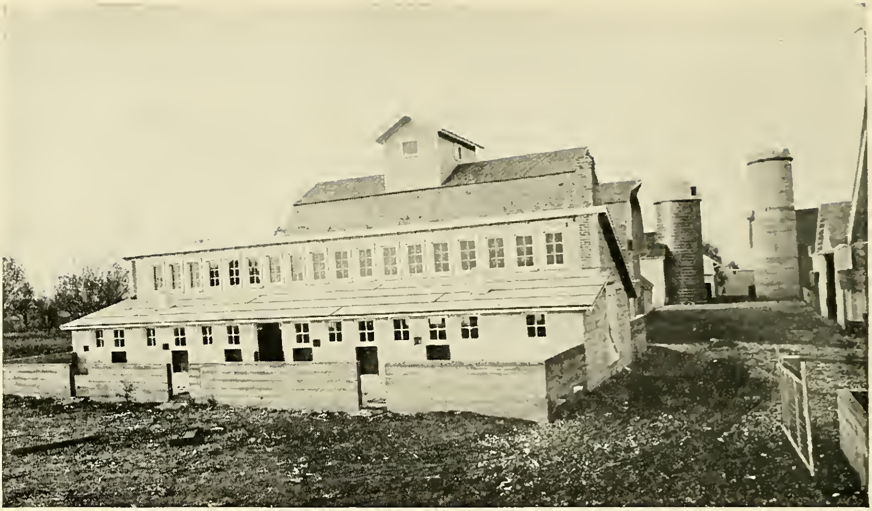
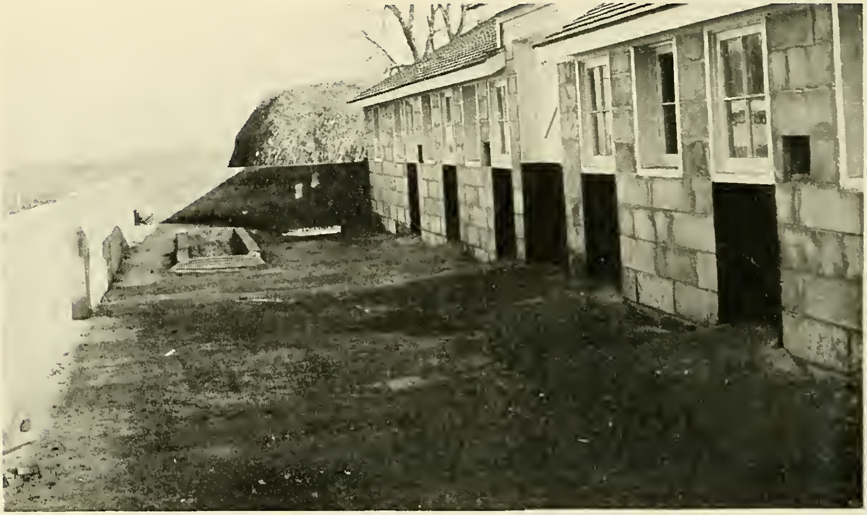


A modern concrete block hoghouse of the half monitor roof type. A well lighted, well ventilated, sanitary, permanent structure which makes an ideal farrowing place for pigs. Concrete feeding floors enclosed with concrete fences are located on two sides of the hoghouse. These paved enclosures are also used as exercising yards for the little pigs. A vat for dipping hogs is built near one corner of the feeding floor. Lower picture shows feeding floor and enclosure walls. *Photos courtesy Hunt, Helm & Ferris Co.*



Concrete on the Hog Farm

IF hog raising is to be made profitable, the animals must be kept healthy. To insure this, sanitary quarters and equipment are necessary.

The feeding floor, wallowing pool, drinking troughs and other convenient and profitable concrete structures desirable on the hog farm are described in this booklet. Consistently used, concrete secures the highest measure of sanitation in and about all hog quarters.

Cholera, white scours, pneumonia and worms are some of the afflictions from which hogs suffer, that are directly traceable to insanitary quarters and surroundings. These diseases annually cost the hog raisers of this country almost unbelievable sums of money. All of them are largely preventable if the animals are provided with clean, warm and otherwise comfortable quarters.

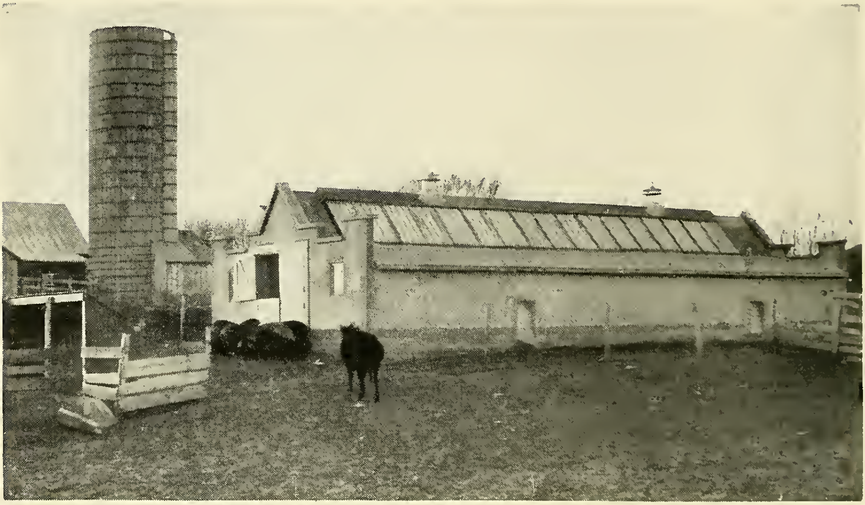
Concrete improvements on the hog farm result in a bigger, healthier herd—more pork, more profits.

From the very nature of concrete, structures built of it do not absorb filth or invite disease germs and vermin to make their home in and about them. Concrete surfaces are easily cleaned and kept clean. Concrete floors and walls may be kept in sanitary condition by occasionally scrubbing down with water to which antiseptic or germicidal solutions may be added if desired. Concrete is rotproof, ratproof, rustproof, windproof, free from all of the usual maintenance required on other types of construction. It makes the expense-proof, permanent improvement.

Hoghouses

Hog raisers have found that the most money can be made from hogs if the litters come during the early spring months. Then the farmer has more time to take care of the little pigs than later when field work more completely engages his attention. Early spring pigs are large enough to turn out to pasture when the pasture lot is ready. They will be ready to fatten in the fall when the corn crop is harvested and when corn is cheapest and may be most readily converted into pork. They can be marketed at good prices before cold weather sets in.

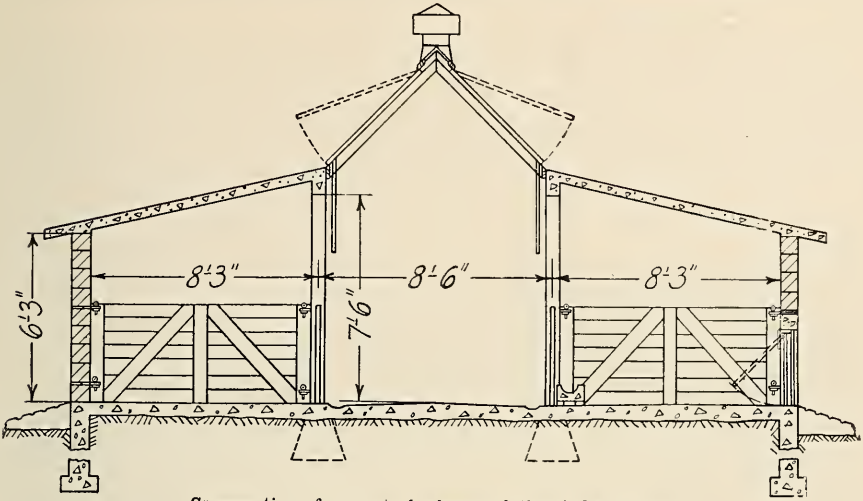
Pigs are worth from $2 to $5 apiece at farrowing time. To save them all and start them out in life with a vigorous constitution requires good care, of which proper housing is an important part.



A reinforced concrete hoghouse of the skylight type, like this one on an Iowa farm, combines maximum cleanliness with maximum of sunlight.

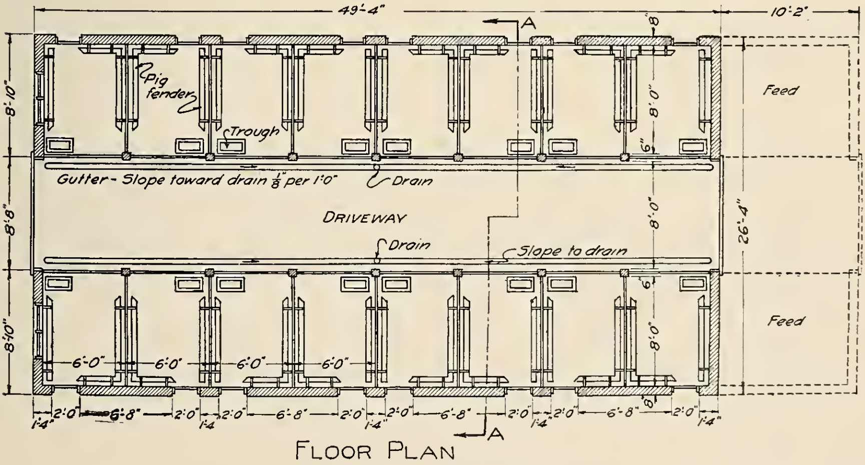
THE SKYLIGHT HOGHOUSE

The skylight hoghouse, so called because of the rows of skylight sash on the roof, which admit light and sunshine, was originated by the Iowa Experiment Station. It is generally located so that the long way of the house runs north and south. Morning sun coming through the windows on the east side of the roof supplies direct sunlight to the west row of pens. In the afternoon the west row of windows enables flooding the east row of pens with sunlight. In this way every portion of the floor is reached at some time during the day by direct sunlight. The little pigs as well as the older ones enjoy the warm spring sun and it helps to make them active and keep them healthy.



Cross-section of concrete hoghouse of the skylight type.

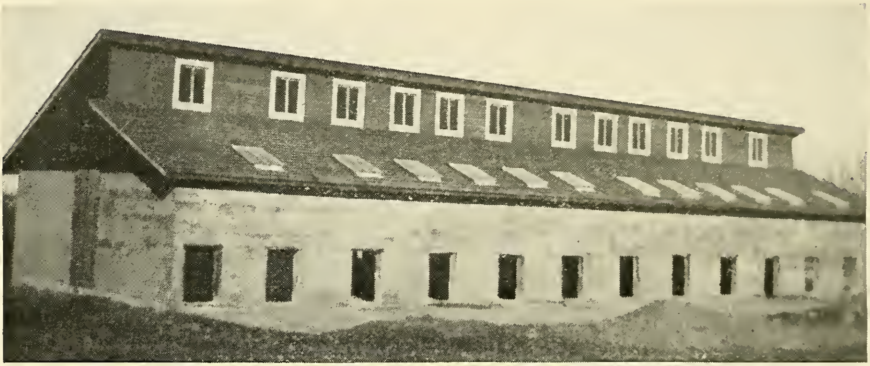
The well lighted hoghouse presents a more pleasant, cheerful aspect also for those who must take care of the animals. Likewise there is no greater enemy of disease germs than plenty of sunlight. As the windows are located in the roof instead of in the walls, the sides of the building are kept low. This results in less overhead space, which insures a warmer as well as a less costly building. In some cases, skylight hoghouses are built with the long way running east and west; then windows are placed on the south slope of the roof. The top row furnishes light for the north pens, and the bottom row, the pens along the south wall.



Floor plan of the skylight type of hoghouse.

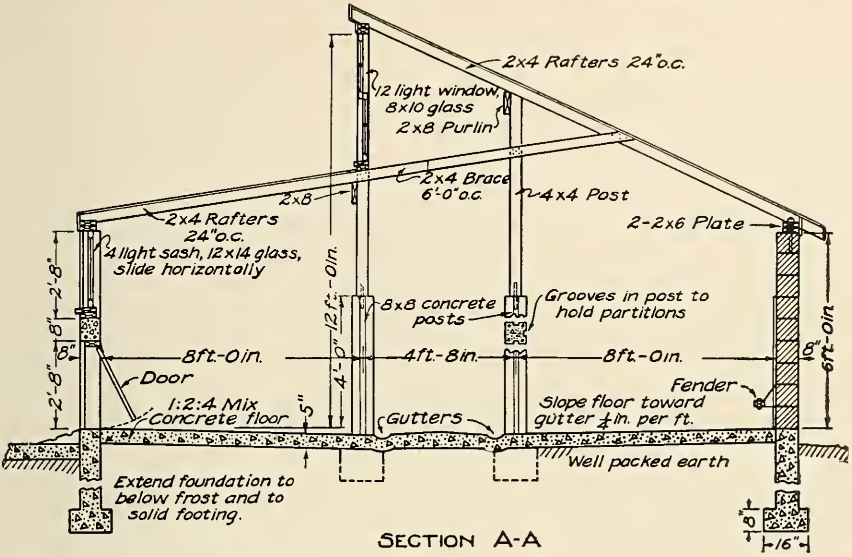
THE HALF MONITOR HOGHOUSE

The popularity of the half monitor roof type of hoghouse is not confined to any particular part of the United States. Everywhere there are hog raisers who favor it. It is always located so that the long way runs east and west with windows on the south side. The top row of windows lights the north pens while the lower row supplies sunshine to the pens along the south wall. The upper row of windows is placed at such a height that the sun will shine on the floor of the north row of pens at farrowing time. As this time will not be the same for all hog raisers and since the sun's rays have a different slant at different seasons and latitudes, the builder should figure out the height at which to place these windows. The following table will be found helpful in determining the height at which to place the upper row of windows. In compiling this table, a distance of 12 feet was assumed from the foot of the windows to the inside face of the north wall measured along the floor. This includes 4 feet for feed alley and an 8-foot depth of pens.



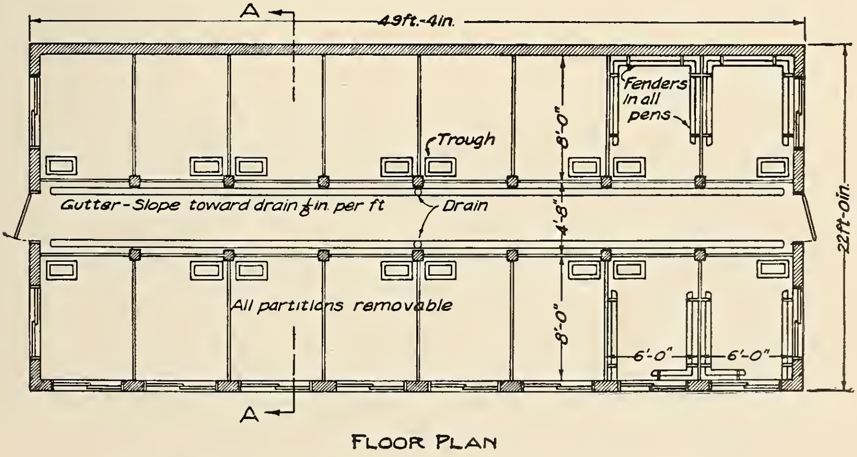
A concrete hoghouse of the half monitor type, on a Nebraska farm, built from plans on following page.

Latitude Degrees N.	HEIGHT TO TOP OF WINDOW							
	Farrowing January 1		Farrowing February 1		Farrowing March 1		Farrowing April 1	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
30	9	0	11	1	15	6	25	0
32	8	5	10	4	14	5	22	11
34	7	9	9	8	13	5	21	1
36	7	2	9	0	12	7	19	6
38	6	8	8	4	11	8	18	1
40	6	1	7	9	10	11	16	9
42	5	7	7	2	10	2	15	7
44	5	1	6	7	9	6	14	6
46	4	7	6	1	8	10	13	6
48	4	2	5	7	8	2	12	7



Cross-section of concrete hoghouse of half monitor type.

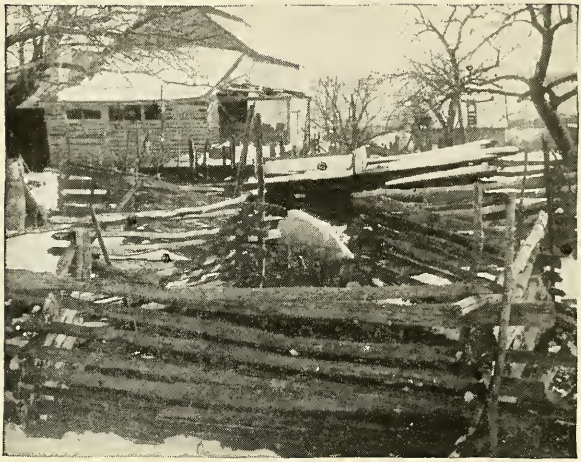
Hog raisers planning to build will be furnished complete working drawings of the half monitor or skylight hoghouse showing floor plans, elevations and other details. Simply write the Portland Cement Association, 111 W. Washington St., Chicago, for free blueprints of hoghouses, stating the type in which you are interested.



Suggested floor plan for concrete hoghouse of the half monitor type.

Concrete Feeding Floors

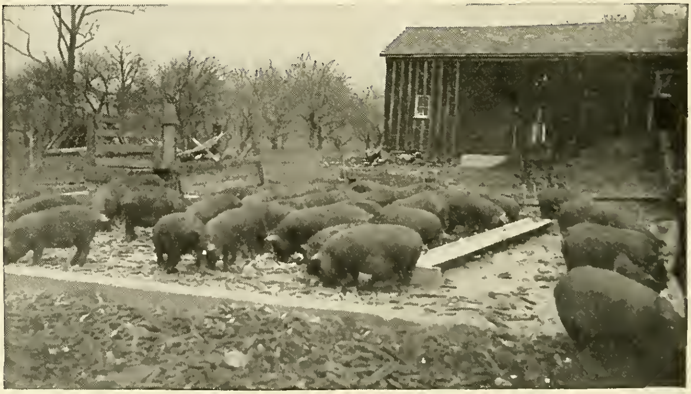
One of the easiest improvements for the hog raiser to build is a concrete feeding floor; and it will bring him quicker and larger returns for the money invested than any other part of his hog raising equipment. Loss of valuable feed is prevented when hogs are fed on a concrete floor. Hogs on a fattening ration, or hogs on full feed, will not hunt for grain trampled into the mud. Besides they should not be made to use up energy that should be converted into pork. The hog feeder cannot afford that waste either. In addition to saving all the feed, a concrete floor helps to keep the hogs in better health. The hog that eats a half mouthful of mud or filth with every mouthful of feed is in constant danger of disease.



Hog quarters such as these do not stand for profitable hog raising.

CONVENIENT LOCATION DESIRABLE

Considerable time and labor will be saved if the feeding floor is located near the corncrib or granary. It is desirable to place the feeding floor on the south or east side of the corncrib or hoghouse, as it



Concrete floor with curb built around the outside to prevent grain from being pushed off and wasted.

will then be largely protected from cold winds. The location selected should be well drained.

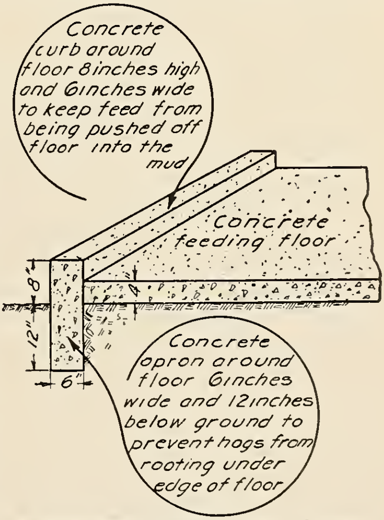
SPECIFICATIONS FOR CONSTRUCTING FLOOR

Where the ground is firm and well drained, concrete may be laid directly upon the soil after all grass, roots and other perishable matter have been removed and the area brought to proper level and firmly compacted.

Even a small feeding floor pays. The floor can be enlarged as the herd increases.

Concrete feeding floors should be made not less than 4 inches thick. What is known as one-course construction, which means the same mixture of concrete throughout, should be used. The mixture should be a 1:2:3, which means 1 sack of portland cement to 2 cubic feet of clean, well graded sand, to 3 cubic feet of clean pebbles or broken stone not to exceed 1½ inches in diameter. Two-inch lumber should be set up for forms and firmly staked to line and grade.

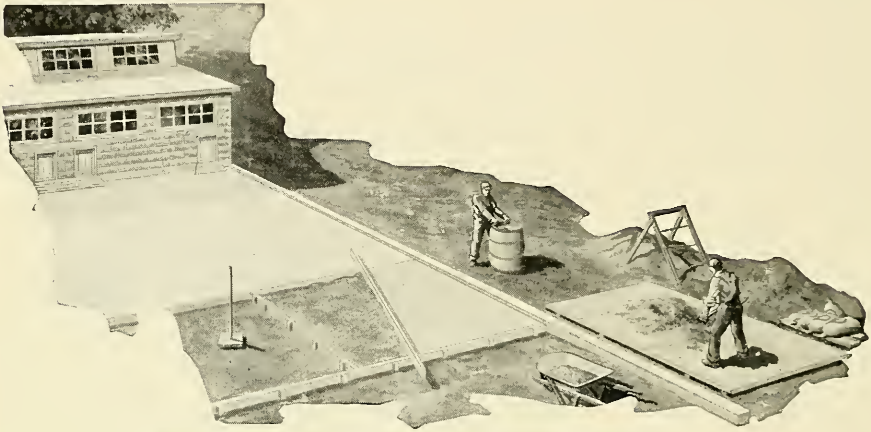
The floor should be sloped in at least one direction so it will drain quickly after rains. Sunshine and rain will help keep the surface clean. A slope of ¼ inch to the foot will be enough. Concreting may be done in strips, just as concrete walks are made, laying alternate slabs first and intermediate slabs later. Slabs should be 10 feet square and joints between them extend clear through to the subgrade. Finishing should be done with a wood float instead of with a steel trowel, so that the even gritty surface thus obtained


Concrete curb around floor 8 inches high and 6 inches wide to keep feed from being pushed off floor into the mud
Concrete feeding floor
8"
12"
6"
Concrete apron around floor 6 inches wide and 12 inches below ground to prevent hogs from rooting under edge of floor

Sketch showing concrete curb and apron construction.

will prevent slipperiness in all seasons and provide a good foothold for the animals.

A curb or apron like that shown in the illustration will prevent hogs from pushing grain off when feeding. This curb or apron should extend 12 inches below ground level to prevent hogs from rooting underneath the floor.



Sketch showing method of constructing concrete feeding floor.

A few hours after concreting has been finished the work must be protected by a covering of moist earth or similar material kept wet by sprinkling for about a week, then the covering can be removed and the floor put into use. Wagons should not be driven over it, however. until it is at least three weeks old.

SIZE OF FLOOR TO BUILD

The following table will be found helpful in determining the size of floor required for different numbers of hogs. It also gives an estimate of the amount of cement, sand and pebbles needed:

Number of Hogs	Minimum Sq. Ft. of Floor Required	Sacks of Cement	Cu. Yd. of Sand	Cu. Yd. of Pebbles
10	150	13	1	1½
20	300	26	2	3
40	600	52	4	6
60	900	77	5¾	8¾
80	1200	103	7¾	11¾
100	1500	128	9½	14½

Each 10 lineal feet of curb and apron requires 2¼ sacks of cement, 4½ cubic feet of sand and 6¾ cubic feet of pebbles.

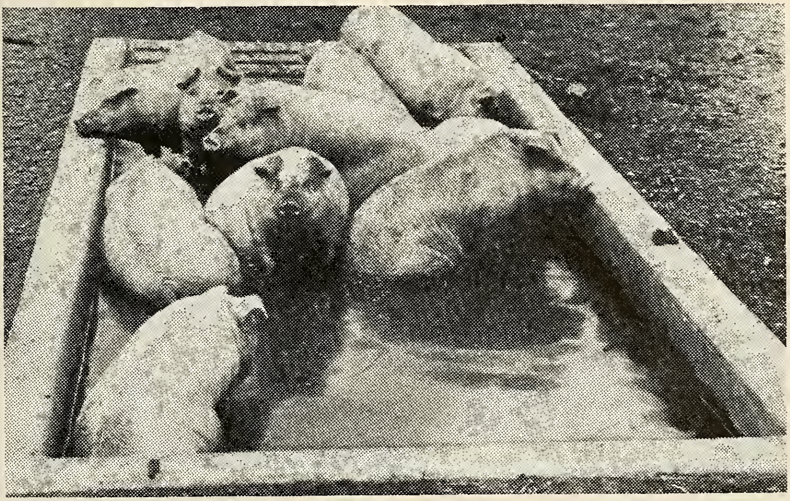
The foregoing is based on a 1:2:3 mixture and a floor thickness of 4 inches.

Concrete Hog Wallow

Hog raisers are beginning to realize how important a concrete wallow is in producing pork for profit. The concrete hog wallow helps to keep hogs in better health and this in turn results in larger gains made more economically. The hog's conformation is such that he eats, drinks and breathes close to the ground. He is therefore very susceptible to diseases which may originate from insanitary surroundings.

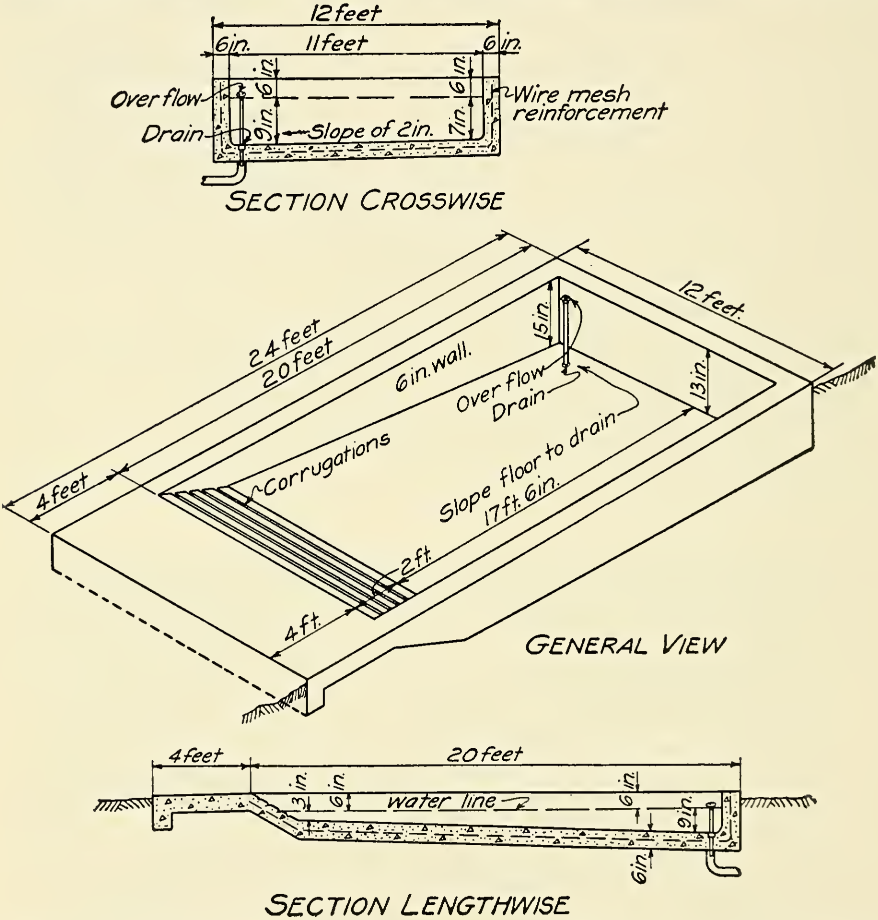
Contrary to common opinion, the hog will keep clean if he has half a chance. When he was domesticated he was taken from his cool shady forest haunts and too often penned up in a filthy sty. We used to think that any place was good enough for the hog. This opinion, however, has proved costly in that many hog raisers have paid dearly for such mistakes in the loss of whole herds by cholera and other diseases directly traceable to lack of sanitation.

Since the wild hog's original stamping ground was the cool shady forest bogs, it is natural to expect that his domesticated descendants have inherited some of his traits. The wild hog lived in wet places to keep cool because Nature did not provide his body with a cooling system like that possessed by most animals. The hog seldom sweats. He must depend upon water or some other cooling agency to keep his body comfortable in hot weather. If he is denied this opportunity, overheating may cause death.



Contentment on every face. By providing a clean wallow the owner has healthier, happier, heavier hogs. The hog makes a mud hole his wallow only when his owner neglects to provide a proper cooling place.

So great is the instinct of hogs to cool themselves by bathing that unless a wallow is provided for them, they will make one for themselves. The shady side of a leaky tank, a spot under the dripping eaves or any pool they can find is too frequently converted into a mud wallow from necessity rather than choice. Such places are always filthy and soon become breeding places for disease. Even though there is a stream of fresh water running through the hog lot, it will pay to build a concrete wallow rather than have the hogs undermine the banks of the stream by rooting. It requires only a few years for a drove of hogs, aided by several periods of high water, to widen a stream from 2 yards to 2 rods. No farmer can afford to have his valuable land taken away from him in this way. Building a concrete wallowing pool for the hogs will prevent it.



General view and cross-sections of concrete hog wallow to accommodate 20 or 30 hogs weighing 200 pounds each.

Mange and insect pests are not nearly so troublesome on hogs that have clean skins. A concrete wallow can be made to serve as a dipping vat by plugging the outlet and pouring dipping solutions on the water, and the hogs will rid themselves of parasites when wallowing.

A hog raiser whose hogs are afforded the comfort and convenience of a concrete pool need not fear that they will fail to gain during the hottest summer months. Hog prices are usually highest in the early fall, making it desirable to fatten hogs during the summer.

SOME CONSTRUCTION DETAILS

A concrete dripping platform or pavement is built at the entrance to the wallow to keep a mud hole from forming when the animals leave the wallow. To make it easy for the hogs to enter and leave the wallow, the floor slopes upward at one end and the surface is grooved to provide a better foothold for them.

Corners inside the wallow should be slightly rounded so the pool can be easily and thoroughly cleaned when necessary. The bottom of the wallow is sloped to give 6 inches greater water depth in the rear than at the entrance, so that large and small hogs can use the pool at the same time.

If the wallow is located near the water supply it can be more conveniently filled. A drain outlet is necessary for emptying the pool. An overflow pipe is also essential. The overflow pipe and drain can use the same outlet. When placing the concrete floor a short piece of drain pipe having a coupling screwed on one end is set in the concrete with the top of the coupling flush with the wallow floor. For an overflow a short piece of pipe 9 or 12 inches long, according to depth of water wanted in the pool, is then screwed into the drain pipe, anchored in the concrete.

For reinforcing the concrete wire mesh reinforcement is specified. The strips of wire mesh should extend across the floor and up into the side and end walls. Concrete mixed in the proportion of 1 sack of cement to 2 cubic feet of sand to 3 cubic feet of pebbles is recommended.

MATERIALS REQUIRED FOR WALLOW ON PAGE 12

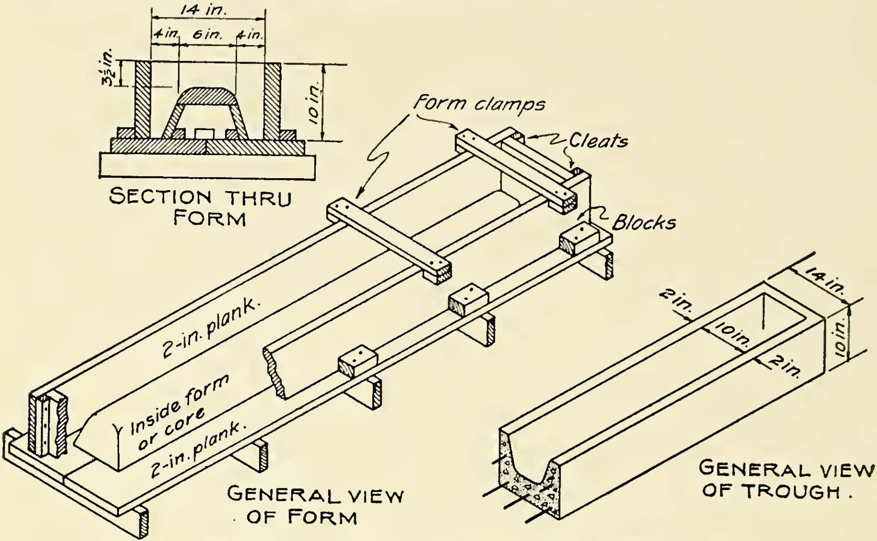
Forty-four sacks of cement; 3⅓ cubic yards sand; 5 cubic yards pebbles; 10 rods 26-in. woven wire fencing.

Concrete Troughs

Concrete troughs have many advantages over those built of other materials. They are easy to keep clean and sanitary. If a concrete trough is left empty, it will not go to pieces in the sun and wind. Its weight prevents hogs from turning it

General view of completed concrete trough built in forms shown on following page.

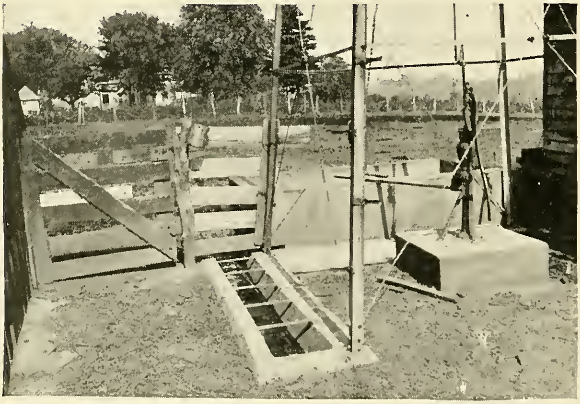
over and rooting it about the pen or yard. Concrete troughs do not rust, rot or warp and are always ready for use.



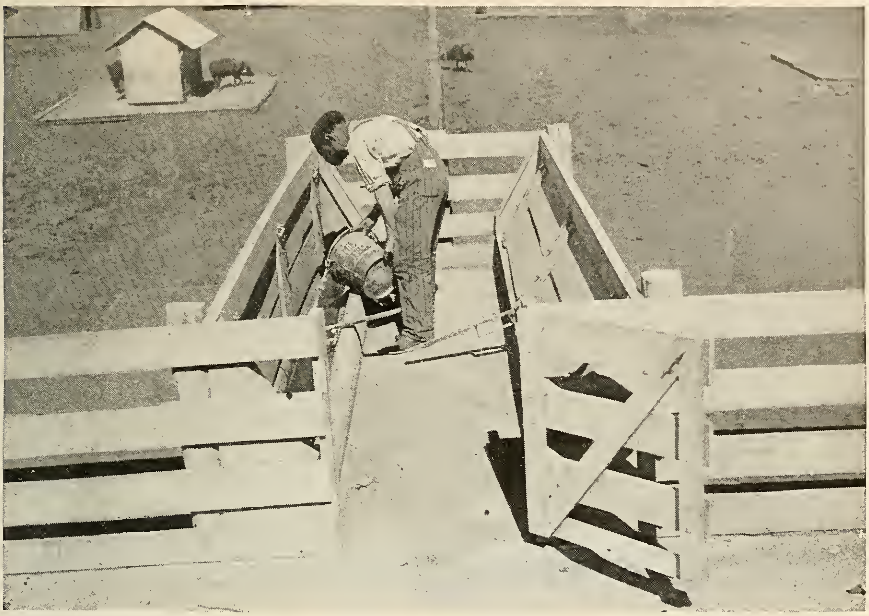
Sectional views of trough and of forms for building it.

One of the simplest and perhaps most useful concrete troughs for the beginner to attempt as his first work of this kind is shown in an accompanying sketch. Such a trough can be cast upside down, either on an even, level barn floor or a platform prepared especially for the purpose. The center sketch gives a general view of the forms and the platform on which they are fixed and supported, while to the right of the group is shown the appearance of the trough after forms have been removed, except that a portion has been cut away to show the reinforcing.

For making concrete troughs a 1:2:3 concrete mixture is preferable; that is, 1 sack of portland cement to 2 cubic feet of clean, coarse, well graded sand to 3 cubic feet of well graded pebbles or broken stone. Sand should range in size from the smaller particles to those that will just pass a one-fourth inch mesh screen. As the sides of this trough are only two inches thick at the top, the largest size pebbles



A concrete trough, like one shown on page 13, placed in proper position for use.



This combination of concrete troughs and feeding floor saves a great deal of labor in feeding hogs at the Illinois Agricultural Experiment Station Farm.

used in the concrete mixture should not exceed three-fourths inch in diameter.

A handy arrangement for feeding hogs originated and used at the Illinois Agricultural Experiment Station Farm is shown on this page. It consists of a concrete feeding floor 12 feet wide and 14 feet long and 2 concrete troughs each 12 feet long made separate from the floor. At the outside corners of the troughs 4 posts are set in the concrete floor. To these are spiked 2 by 8 inch pieces which support panels which can be swung over the troughs. This feature enables the herdsman to keep the hogs away from the trough while it is being filled. A strap iron fixture holds the panel in the position desired.

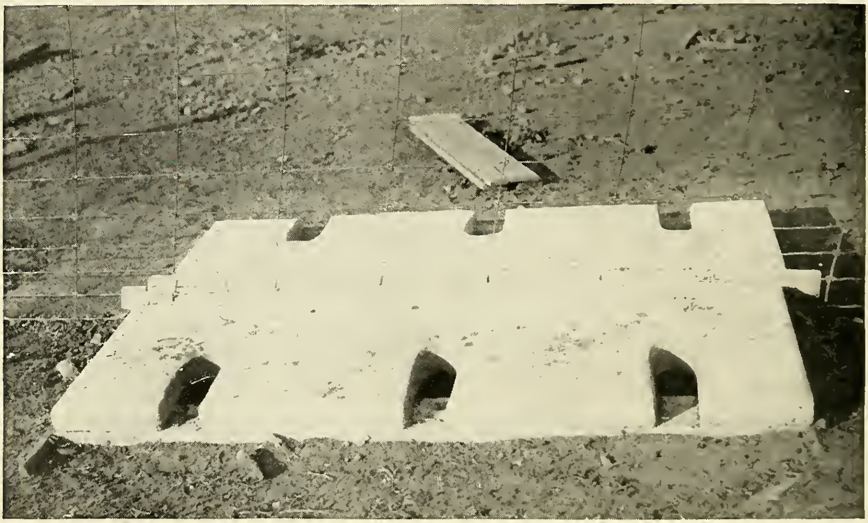
Simple directions for building a feeding floor like this one are given on pages 8 and 9. The troughs used may be made like the one described on page 14.

Ten of these troughs have been in use at the University of Illinois for 4 years and are in excellent condition. They were built by a man who had never before done any work with concrete.

The hog is one of the best money makers on the farm. Yet it is easy to lose money on hogs unless disease is prevented by cleanliness, unless parasites are controlled by sanitation, or unless the feed bill is held down. These preventive measures are all accomplished by concrete improvements such as those here described.

Concrete Hog Waterer

Every hog raiser realizes the importance of having an abundant supply of clean, fresh water for his animals. Hogs drink frequently when water is at hand. Drinking from streams is a dangerous practice, as the water may have become contaminated by diseased hogs or filth from above. An automatic hog waterer assures a plentiful supply of clean, fresh water at all times. There will be no fighting of animals as is sometimes the case when hogs are watered by hand. The weakest animal gets all he wants as well as the biggest, strongest one.



A concrete hog waterer, like this one, promotes health and contentment among the hogs by providing an abundance of pure, cool water at all times.

A serviceable type of hog waterer is illustrated above. It consists of a shallow concrete tank from 8 to 10 inches deep, covered by a concrete slab. In the cover are 6 drinking holes. The cover slab is cast in two sections and is made removable so that the trough may be cleaned when necessary. The tank is kept full at all times by means of a float arrangement. In such a device water keeps clear and cool in summer. By covering all drinking holes but one or two, and banking with straw, it will not freeze in the coldest weather. This concrete waterer will not leak, rust or rot—serviceable the year round.

To lighten farm work indoors as well as outdoors, improve your farm with concrete walks from kitchen door to the well, granary, corncrib, barn and hoghouse.

Concrete fence posts keep animals where put and protect growing crops from destruction.

Concrete Fence Posts

For keeping hogs where they are wanted, there is nothing quite so satisfactory as concrete fence posts and hog tight woven wire fencing. Whether hogs are in a dry lot, out on pasture or "hogging down" corn they will stay where put when enclosed with a fence of this description.

Concrete posts also "stay put" for they do not rot, rust or burn—but grow stronger with age. Frost will not heave them and lift up the fencing so that hogs can crawl through.

Trash and weeds along fence rows can be burned off without danger to concrete posts. Billions of weed seeds and the eggs of insect pests can thus be destroyed as well as to make the fence line attractive.

Concrete posts are easy to set. Because of the smooth, regular outline the hole required is small. They are easy to line up due to the straight, even size and uniform height. They can be made during spare time or in the winter.

Our booklet No. P-5 gives complete instruction for making concrete line posts, corner posts and gate posts. Copies may be secured free of charge. Address our nearest District Office.

A fence line with concrete posts is proof against destruction by water, frost, fire or age.

Concrete Corncribs

Concrete makes an ideal crib for corn. Rats and mice can not gnaw through concrete. It has been estimated that every rat in the United States eats or destroys $4 worth of feed in a year. Let him make his home in a corn pile and he will spoil more than $4 worth. Rats also are spreaders of hog cholera.

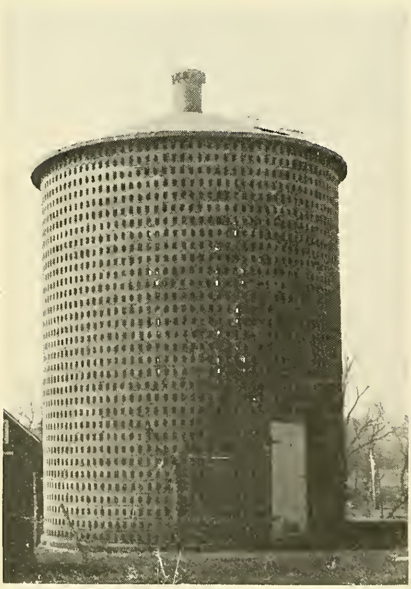
Concrete is the most economical and effective rat fighter that we have. Farms that were once almost at the mercy of these pests have been made ratproof by building concrete foundations and floors and in other ways using concrete to deprive the animal of nesting and breeding places and food.

Like all concrete farm buildings, corncribs built of concrete are permanent and protect their contents against loss by fire. Also, there will be no paint bills or costly repairs to make—the first cost will be the only one.

Several types of circular cribs have been developed. A round structure requires less building material for the same capacity than one of any other shape. Some builders claim that circular concrete corncribs can be constructed at less cost per bushel of storage capacity than rectangular wooden cribs.

ROUND CONCRETE BLOCK CRIB

A very desirable round crib is illustrated here. This is 18 feet in diameter, 24 feet high to the roof and will hold 2,500 bushels of corn. The block from which it is made are 24 inches long. They lay up in the wall 8 inches high and make a wall 4 inches thick. Each block has three full holes and two half ones, each hole being 2½ by 4½ inches. Holes have a slight slant at the bottom so that rain will drain outward.



This concrete crib keeps corn in perfect condition and protects it from rats and fire.

At the center of the crib is a chute 2 feet square built of block similar to those in the exterior wall. On top of this chute and extending through the reinforced concrete roof is a 24-inch concrete pipe which forms an outlet for the ventilating flue.

Walls are reinforced with steel hoops embedded in the horizontal mortar joints. The inside wall of the crib is lined for a few feet above ground level with ¼-inch galvanized wire mesh to keep rats and mice from entering through the openings provided in the blocks for ventilation.

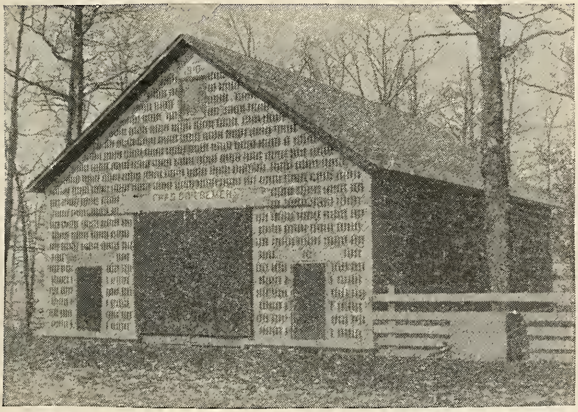
CEMENT STAVE CORNCRIB

Cement stave corncrib, 12½ feet high by 21 feet in diameter. Approximately 2,000 bushels of corn can be stored in this ratproof crib.

A corncrib built of concrete staves similar to those used in silo construction is shown here also. The staves are 30 inches long, 10 inches wide and 2½ inches thick. They are set up in the same manner as when used in the construction of a silo and held in place by steel bands or hoops. Openings in the staves are 4 inches wide and 9 inches long. Staves are reinforced with four ¼-inch twisted steel bars which are so placed that they run the length of the openings, and make them rat and mouseproof. At the center of the crib is a ventilating flue connected with several flues formed by lines of 8-inch drain tile laid under the concrete floor and running radially from the center of the crib to the foundation wall. The flue shell is built of hollow concrete block laid on their sides so that it has lateral openings every 8 inches on all sides. This gives uniform and constant ventilation.

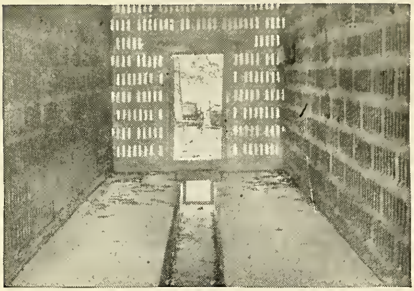
DOUBLE CRIB

Many corn growers favor a rectangular corncrib with a driveway running lengthwise through the center. The accompanying illustrations are of a concrete block crib of this type. The cribs are generally made about 8 feet wide and long enough to give the capacity desired. The driveway should be 10 feet wide and have 10 feet of headroom to give ample space for loaded wagons. An elevator is sometimes in-



Double corncrib of the concrete block type on an Illinois farm that has built out the rats.

stalled in the driveway for conveying the ear corn into the cribs. Bins for holding grain are frequently built over the driveway. These are filled with the elevator and emptied through spouts in the bin floor.



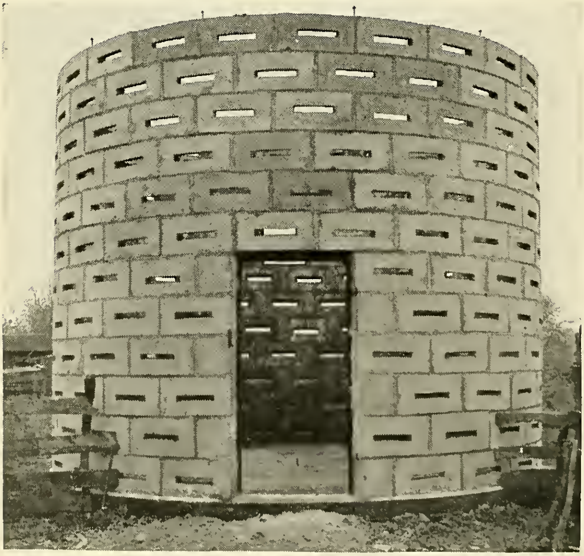
Interior view of one side of a double crib.

The concrete lined trench seen in the picture is built so that the extension feeder of the corn sheller can be placed in it when shelling out the crib. Short pieces of board laid over this trench are removed as fast as the corn can be shelled. Such a trench is a labor-saving feature that should be built in every corncrib from which corn will be shelled.

The smooth concrete floor in this crib has no projecting nail heads to aggravate the man using the scoop shovel. Practically all modern corncribs are built with concrete floors as it has proved to be the material best suited for this purpose. It is advisable to have the floor about one foot higher than the surrounding grade. This gives good drainage from beneath the floor.

Concrete mixed in the proportions of 1 sack of cement to 2 cubic feet of sand to 3 cubic feet of pebbles is recommended for floor construction. A smooth surface finish is desirable as it will not wear out the scoop shovel when sliding over it.

Another type of circular crib of recent development is shown on this page. This crib is built of reinforced concrete blocks 4 inches thick, 12 inches high and 24 inches long. An opening in the center 2 inches high and 14 inches long is provided for ventilation. The lower edge of this opening is beveled so that water from driving rains will drain outward.

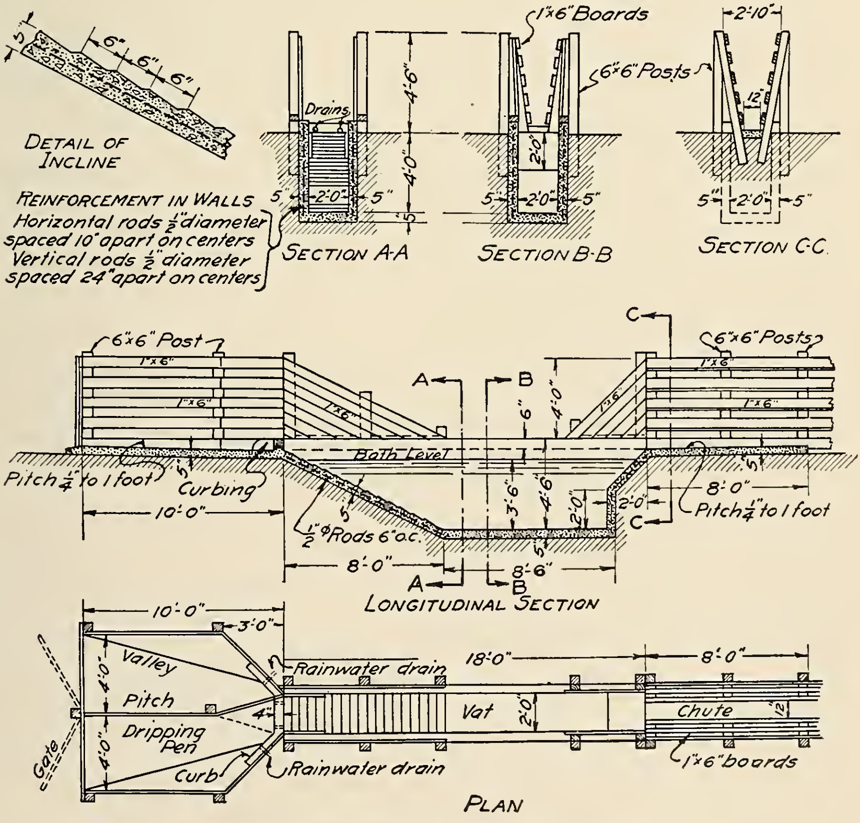


Reinforced concrete block corncrib under construction.

Rats and mice are kept out by ¼-inch galvanized wire mesh embedded in the lower three tiers of block. The crib illustrated is 15 feet in diameter and 12 feet high. A ventilating flue is built in the center so that the pile of corn will in no place be more than 7 feet thick.

Concrete Dipping Vat

Dipping hogs in a concrete vat filled with an insecticidal solution is the only sure way to rid the animals of lice, fleas and mange. These parasites are very common to hogs and frequently cause serious losses to the hog raiser. Hog lice are especially troublesome. They are blood sucking parasites found around the animal's ears, inside the legs and about the flanks. They stay in these places because the hog cannot reach and disturb them. Naturally they cause hogs considerable annoyance and irritation and so retard growth. To free a hog from lice he must be dipped in a vat where the solution can reach every part of his skin. Rubbing poles and self-oiling devices help, but do not accomplish as thorough treatment as a dipping vat. A suggested plan for a concrete hog dipping vat is presented below. Blueprints of this design will be sent free on request to persons planning to build. Address Portland Cement Association, 111 West Washington Street, Chicago.



Suggested plan and cross-sections of concrete dipping vat.

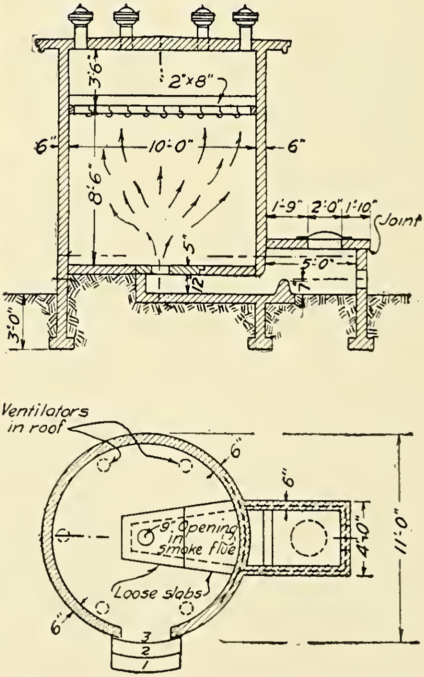
Concrete Smokehouses

There is no reason why a farmer should not have a plentiful supply of home cured meats on hand. There was a time when the smokehouse was recognized as an important farm building. One should be on every farm where hogs are kept and can readily be slaughtered to provide the home supply of meat.

Cement staves used to build a small farm smokehouse.

Many types of smokehouses are in use, ranging from an ordinary barrel with one head knocked out to a well-equipped, permanent concrete structure. There is no danger of a concrete smokehouse burning down, thus resulting in a loss of the winter's supply of cured meat. It also keeps out rats, mice, dogs, cats and the human variety of thief.

Rectangular monolithic concrete smokehouse. There ought to be a smokehouse on every farm where hogs are raised.



Section and plan of circular monolithic concrete smokehouse that can be built by using silo forms.

Accompanying drawings show a small circular concrete smokehouse suitable for the average farm. The fire pot is placed outside where the fire can easily be controlled and replenished. This arrangement also furnishes cooler smoke, which results in keeping the inside temperature down, thus causing less dripping of fats from the meat while curing. Ventilators are placed in the roof so that the amount of smoke in the house can be regulated at all times.

Several cement stave silo builders have found it profitable to build cement stave smokehouses during the slack season. One shown here was built by Fred Traub, of Doon, Iowa. A structure of this type can be put up very quickly and at low cost.

It may sometimes be desirable to build a smokehouse of rectangular or square section, but the circular structure assures a more nearly uniform distribution of smoke, consequently the meat is all cured alike. Complete building plans of a concrete smokehouse, showing details other than those reproduced here, can be obtained free from the Portland Cement Association.

Concrete Brine Tanks

Concrete vats are being used extensively as pickling vats to cure ham and bacon. They do not rot, rust or leak and they last indefinitely. A concrete vat is always clean and does not absorb or retain objectionable odors usually common to the old brine barrel. The concrete tanks or vats illustrated are three feet square at the top and four feet deep. The inside walls are battered and vary in thickness from three inches at the top to four inches at the bottom. Vertical reinforcing is one-fourth inch square bars spaced six inches center to center and horizontal reinforcing is three-eighths inch square bars spaced six inches apart. A 1:2:3 concrete was used.

Concrete meat pickling vats in market in Huron, S. Dak.

Well planned concrete buildings will do more than anything else to put farm prosperity on a permanent basis. Concrete requires no profit-consuming maintenance. It puts staying power into the bank account.

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Durability, Fire-safety, Sanitation and Economy are qualities characteristic of well-built concrete structures. We place at your disposal **definite information on the use of concrete** so that these results will be assured.

Our District Offices listed below are service organizations. **Get their help in your concrete problems.** In addition you are invited to correspond with our headquarters, 111 West Washington Street, Chicago, where our engineers specialize in the application of concrete to

Farm Improvements
Home Building
Sanitary Improvements
Roads and Streets
Railway Construction
Industry and Commerce

These engineers are constantly in touch with the extensive researches being made by the various government bureaus, and by the Structural Materials Research Laboratory, operated jointly by us and the Lewis Institute, Chicago. Their recommendations are based on the most advanced information obtainable.

Educational booklets and pamphlets fully illustrating and describing the important uses of concrete await your request. Consult us freely.

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Massachusetts Agricultural College,
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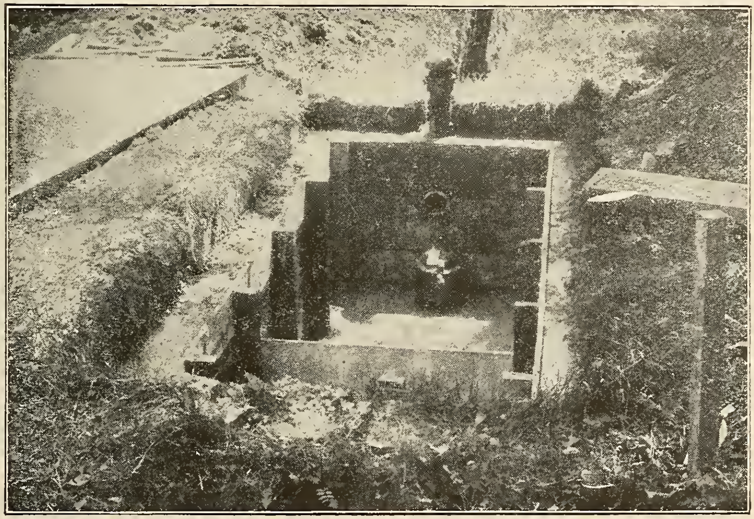
Concrete Septic Tanks

A sanitary method of sewage disposal where the advantages of a city or town sewerage system are not available.



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Concrete Septic Tanks

There is no greater enemy to health than the outdoor privy. In many cases the spread of typhoid fever, dysentery, so-called summer complaints and the hookworm disease of the warm southern states, has been traced directly to such a source. Careless methods of disposing of wastes from the human body, as well as garbage and other refuse of housekeeping, have caused epidemics of disease with awful waste of human life.

In many sections of the country, health authorities will not permit the use nor existence of an outdoor privy. It is certain, sooner or later, to foul drinking water and so be the cause of disease. The cesspool also should be forbidden. It must be emptied at regular intervals and safe disposal of its contents is a hard problem.

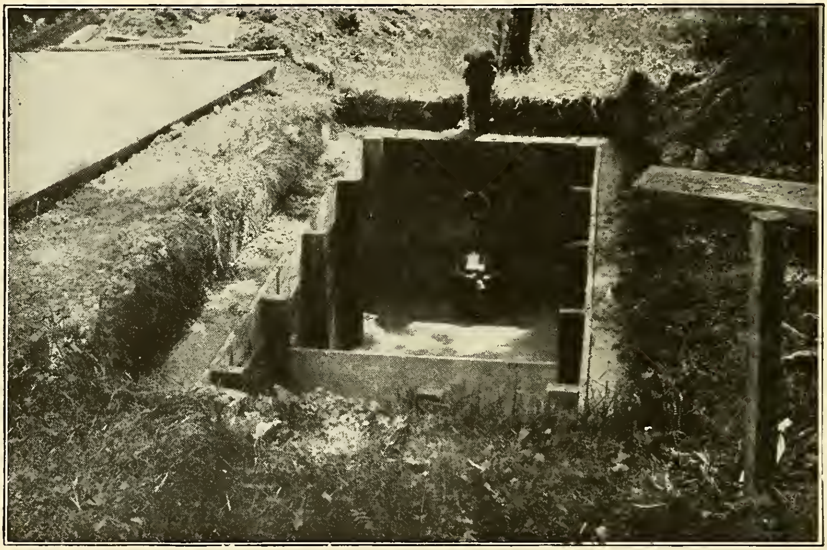

Figure 1. View of Concrete Septic Tank as it appears previous to building cover slab.

Every home should have the indoor toilet, bath and kitchen sink. The farmer or small town dweller wants and deserves these little comforts which are enjoyed by his city friends. He can have them just as easily and with as great safety as the city dweller.

Concrete septic tanks solve the problem of disposing of house wastes from a modern plumbing system where a city sewer is not within reach. It must be understood, however, that the concrete septic tank is not offered as a substitute for a modern sewerage system. It is intended only as the best substitute where the city sewerage system cannot be made use of. Properly built and taken care of, a concrete septic tank has many advantages over the cesspool. A concrete septic tank will transform the wastes from the house plumbing so that their final disposal in a safe, sanitary manner is very simple.

Concrete septic tanks are not hard to build nor are they expensive. Once in operation, they cost little or nothing to keep in order and may be relied upon to give satisfactory service indefinitely.

Usually a septic tank is built of two compartments, as shown in a sectional view at the upper center of the illustration on pages 4 and 5. The first or left-hand compartment is sometimes referred to in several ways. Generally it is called the settling chamber. The second, or right-hand compartment, which is smaller than the first, contains a device known as a siphon, and for that reason is called the siphon chamber. The siphon chamber receives the overflow from the first compartment, and by means of the siphon, which is automatic in operation, is emptied at regular intervals into a tile line which leads to a disposal field where the discharges leak out through the open joints of the tile line and so seep into the soil.

The principle on which the septic tank operates is one of rotting or decomposition; that is, the solids and semi-solids which enter the first compartment from the house drain are digested or liquified by bacteria such as develop in all vegetable or animal matter when such matter starts to rot or decompose.

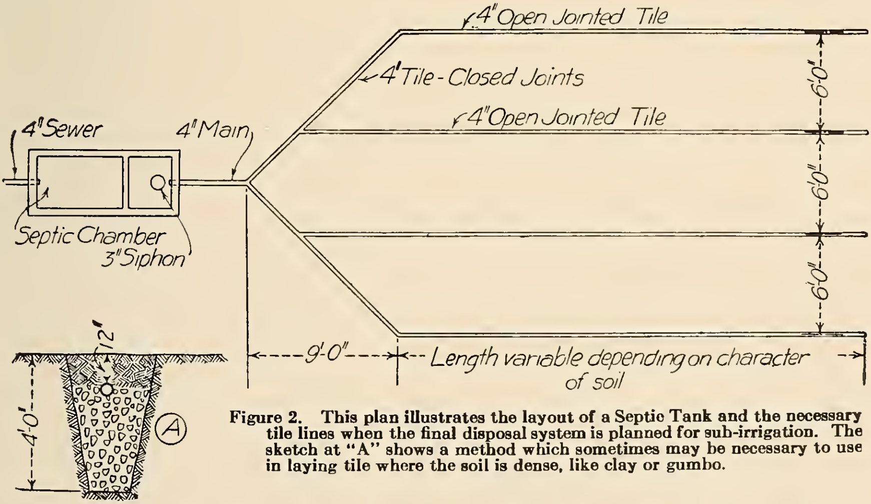

Figure 2. This plan illustrates the layout of a Septic Tank and the necessary tile lines when the final disposal system is planned for sub-irrigation. The sketch at "A" shows a method which sometimes may be necessary to use in laying tile where the soil is dense, like clay or gumbo.

Experience has proved that in the septic tank, sewage will, if confined in a practically airtight and dark compartment, soon commence to "break up" in this manner, due to the development and action of these bacteria. These feed, so to speak, upon the solids and semi-solids in the wastes, thus

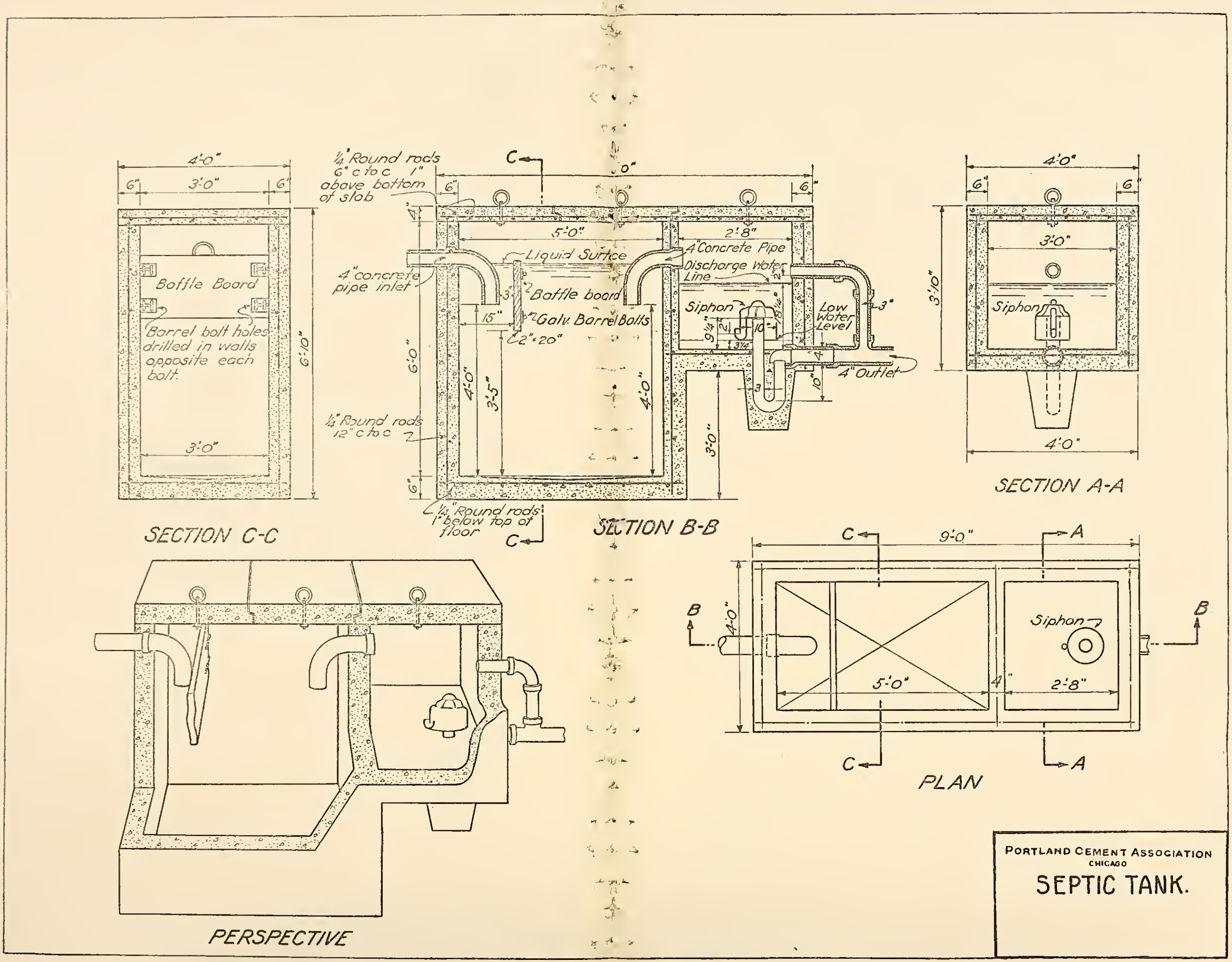

Figure 3. Design for Concrete Septic Tank.

converting them into gas and relatively harmless compounds. It should not be thought from this, however, that the action taking place in the tank will destroy disease germs. The discharges from the tank through the operation of the siphon must still be properly cared for to prevent them from being a possible source of disease.

Although the plan shown on pages 4 and 5 may be changed in a number of ways without affecting the successful operation of the septic tank, practically all designs for such structures make use of the principal points or features illustrated.

Sewage must enter from the house at one end of the tank and leave at the other end. A grease trap must be placed in the line from house to tank. The flow through the tank should be slow and as uniform as possible. If the flow is not slow, the solid matter will not settle. Rapid flow in the center and no movement at the sides interferes with the most effective working of the bacteria that develop in the scum which forms on the liquids in this compartment a short time after the tank is put into operation. Sewage must enter the tank below the normal level of contents.

A rectangular tank is best. The depth should be not less than 4 feet below the opening of the pipe which discharges wastes into the tank. The total depth of fluids in the first compartment should be not less than 5 feet and, where practicable, a greater depth is to be preferred. Baffle boards are usually placed, as shown in this plan, to prevent the incoming wastes from the house from breaking up or otherwise disturbing the scum on the liquid in this compartment, and also to prevent any of the scum from being carried over into the siphon chamber. After having remained in the first compartment a sufficient length of time, the solid matter which the wastes contained has been destroyed and the liquids overflow into the siphon chamber.

Two methods are commonly depended upon to dispose of the discharges from the siphon chamber resulting from the frequent emptying of this compartment by the automatic siphon. If the surroundings are such that a certain area of ground can be set aside for the purpose, surface, or broad irrigation, as it is called, is a satisfactory means of disposing of tank discharges. This means allowing the liquids discharged by the tile line from the siphon compartment to flow over the land where they are acted upon by the sun, and by bacteria which live in the upper layers of the soil and require air at least for their life and work. Therefore the soil cannot handle these wastes properly below a certain distance from the surface, because of limited air supply. In the final disposal of sewage by broad irrigation, it should be the aim to select an area, or disposal bed as it is sometimes called, where the wastes will not be washed immediately into some nearby stream, thus fouling the water.

Discharges from the siphon compartment should be carried to the disposal field by a tile line made of dense, non-porous tile, laid with cemented joints. The outlet should discharge into an open ditch which may be about 12 inches wide by 6 inches deep, with side ditches connecting to this main one at right angles and at intervals about 6 feet apart. These should be dug to such a grade that the fluids will quickly and easily spread over the whole area. Rapid distribution of the liquids is necessary to prevent the soil from becoming clogged up as it would if a small area of the field had to receive and dispose of all the discharges from the tank. Where possible to do so, it is advisable to provide two or even three disposal areas so that one or two can be "resting" while the other is in use. This also will prevent the soil from becoming clogged.

Another method of final disposal consists of what is called subsurface irrigation. This means discharging the contents of the siphon compartment into lines of 4-inch drain tile laid with open joints so that the liquids may leak out of these joints and filter into the soil. Such a tile should be laid with a grade not greater than 2 inches per hundred feet. To prevent soil from entering the tile line through open joints and thus clogging it up, joints may be covered with flat stones or pieces of broken tile of larger diameter. In both systems all connections between the house and septic tank and from the septic tank to the disposal field should be made with tight joints. This means that there should be at least 200 feet of tile laid from the siphon chamber before the sewage is discharged into open trenches or before the tile are laid with open joints.

The general method of laying tile lines where subsurface disposal is followed is shown in Figure 1. As a rule, subsurface disposal is best for the single residence if soil conditions are suitable. This system usually requires less attention, and the discharges from the tank are entirely out of sight at all times. Where firm or dense soil such as clay or gumbo exists, it is best to follow the plan illustrated at (a) Figure 1. This shows a deep trench partly filled with gravel or cinders. On top of this fill a tile line is laid and the remainder of the trench filled with earth. In very heavy soils an additional line of tile in the lower portion of the trench may be used to make drainage more free.

Once started, the septic tank is self-operating on account of the automatic siphon. Being discharged at intervals from the siphon compartment, the tile line is suddenly flushed, then emptied by leakage out of joints into the soil, hence the soil is allowed to rest until the next discharge brought about by the siphon. These intermittent discharges keep the soil from clogging, as would happen if the tank were continually discharging a trickling flow into the tile line.

Experience seems to prove the advisability of building a septic tank with a capacity sufficient to handle a 24 hours' flow of sewage or wastes from the average household. Capacity is usually estimated by considering that the discharges into the tank will range from 30 to 50 gallons per person per day. The length of the tank should be about twice the width, so that it will be possible to obtain a uniform velocity of flow through it. This will prevent any great disturbance of the scum.

In the plan shown on Figure 2, the bottom of the first compartment is sloped toward a center drain fitted with a plug. This drain is convenient when cleaning out the tank, to carry away the settlings that gradually accumulate at the bottom of the tank. These settlings are known as "sludge" and consist principally of humus that is not digested or rotted by the ordinary bacterial action taking place in this compartment. In some cases the floor of the tank is given a slope in one direction only, and the drain provided for cleaning, when necessary to do so, is therefore placed at one side or near one corner of the tank. The capacity of the siphon chamber should be such that the siphon will operate to empty this compartment at intervals of from 4 to 6 hours. The more nearly square the siphon compartment is, the easier will it be to build it.

Automatic siphons are manufactured by a number of concerns.* For ordinary installations a 3-inch Miller automatic siphon may be used. These have no moving parts and require very little attention.

Septic tanks can best be constructed of concrete, particularly because they must be watertight. If a 1:2:3 concrete is used, this end will be secured. The mixture mentioned means 1 sack of portland cement, 2 cubic feet of clean, coarse sand, evenly graded from the fine particles up to those that will just pass a ¼-inch mesh screen, and 3 cubic feet of clean, well graded pebbles or broken stone, the particles of which vary in size from ¼ to 1¼ inches. Enough water should be used to produce a mixture of quaky consistency, so that the concrete when placed will settle to all parts of the forms when slightly jogged or puddled with a spade or similar tool. Reinforcing, of course, must be chosen and used in accordance with the size of the particular tank. These details, including full directions for the various operations in constructing the tank illustrated, will be supplied on request after you have decided upon the type and size of tank that is necessary to handle the wastes from your house.

Septic tanks have sometimes failed to work properly because the type of tank or method of final disposal selected was not suited to the local soil conditions. For this reason we advise those thinking of building a septic tank to write to their state or local health authorities who will be glad to advise as to the best system for each particular situation. Practically all state boards of health issue bulletins treating of the sanitary disposal of household wastes. These bulletins may be obtained free by addressing your state board of health.

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*NOTE—Automatic siphons may be obtained from the following firms:
Pacific Flush Tank Co., Chicago.
Merritt & Co., Philadelphia, Pa.
The Hendrie & Bolthoff Manufacturing & Supply Co., Denver, Colo.
S. Story & Sons, Cedar Rapids, Iowa.

Massachusetts Agricultural College,
AMHERST, MASS.

CONCRETE SILOS

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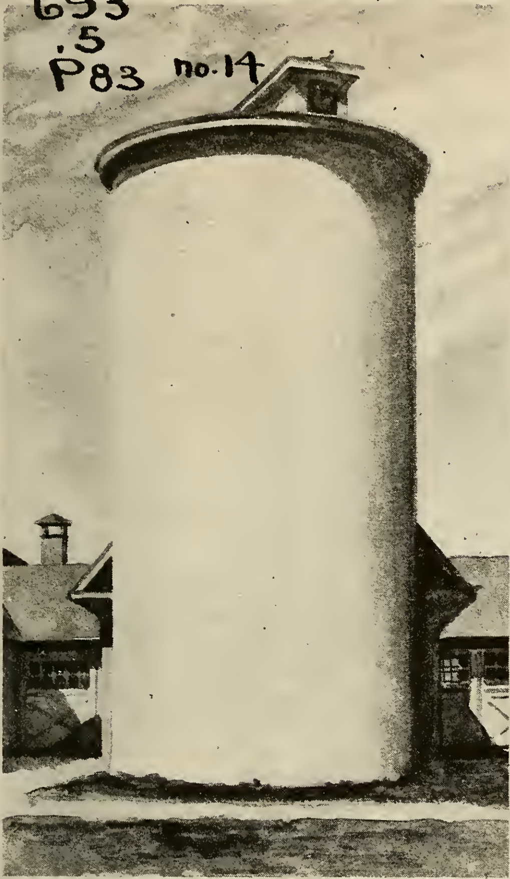
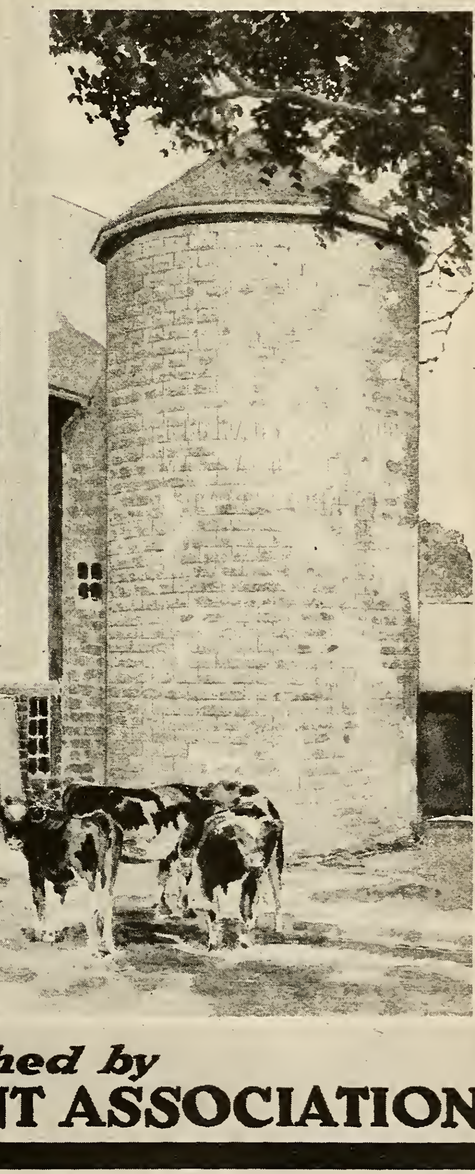
MONOLITHIC AND BLOCK





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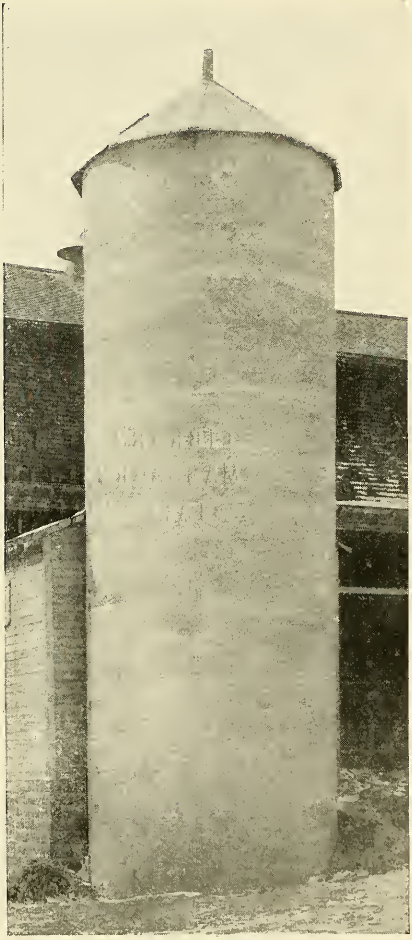
Concrete Silos

Monolithic and Block

The Ideal Silo

The ideal silo is one which, besides keeping silage perfectly, gives its owner the longest period of service at the lowest cost.

To keep silage in good condition the silo must be so built that the natural moisture in the silage will be retained. Air must be excluded and the silage must be able to settle freely and uniformly, thus preventing the formation of air pockets.



A silo increases the productive capacity of the farm, makes stock feeding economical and profitable, and makes possible a maximum output of dairy products.

In order that silage may settle freely to utmost compactness, the cylindrical form of silo (most readily constructed in concrete) is preferable.

To insure long life at low cost the silo must be windproof, verminproof, reasonable in first cost, practically free from maintenance, and fireproof.

Two of the most desirable advantages of a concrete silo are its ability to withstand windstorms and its fireproofness. Fire is one of the most serious dangers with which the farmer has to contend. A concrete silo being fireproof will protect its contents against loss by fire and frequently serves as a barrier to prevent fire from spreading from one wooden building to another inflammable structure. The weight of a concrete silo, even when empty, makes it so stable that no instance is known where a concrete silo has been blown down.

The concrete silo readily fulfills all requirements of the ideal silo.

Every Silo Should Be As Nearly Permanent As Possible

When buying a silo the farmer should take into consideration the probable number of years of service he can expect from the various types from which choice may be made. The silo that lasts only a few years is usually most expensive in the end, no matter how low priced it may have seemed when new. A good way to arrive at the real cost of a silo is to figure it on a yearly basis and divide the first cost by the life of the silo in years. Because a concrete silo is permanent, the annual cost is very low. The first cost is the only one because concrete requires no painting, repair or other upkeep.

While it is usually desirable to employ a contractor, concrete is well adapted for the silo requirements of the farmer who desires to do the building himself. With the exception of some one familiar with the use of concrete to superintend the job, no skilled labor is needed. The farm hands can do practically all of the work. Usually sand and pebbles are on the farm or near by and rarely cost more than the labor of digging, screening and hauling.

The concrete silo, monolithic or block, fulfills all the requirements of the ideal silo—satisfactory service, long life, lowest cost.

What Size of Silo to Build

Diameter and height of the silo will depend upon the number of animals to be fed and the length of the feeding period. Diameter chosen should make it possible to feed at least a 2-inch depth of silage each day.

Locating the Silo

Practically all silos are built near the barn and connected to it by a short passageway. A very common arrangement is to locate the silo so that the passageway from it will be continuous with the feed alley in the barn. Convenience in feeding should have first consideration when location is being considered.

From tables 1, 2 and 3 it is possible to select the exact size of silo required to meet the conditions of any given case.

Table 1

DIAMETER OF SILO REQUIRED TO FEED VARIOUS NUMBERS OF ANIMALS

Diameter in Feet	Approximate Minimum Pounds to be Fed Daily	Minimum number of each kind of Stock to be Fed from Each Size Silo					
		Dairy Cows	Beef Cattle	Stock Cattle	500-lb. Calves	Horses	Sheep
10	525	13	21	26	44	48	175
12	755	19	30	38	63	69	252
14	1030	26	41	52	86	94	344
16	1340	34	54	67	112	122	446
18	1700	42	68	85	142	155	567
20	2100	53	84	105	175	191	700

Table 2

APPROXIMATE CAPACITY OF ROUND SILOS

Height of Silo Feet	Inside Diameter of Silo in Feet and Capacity in Tons					
	10 feet Tons	12 feet Tons	14 feet Tons	16 feet Tons	18 feet Tons	20 feet Tons
28	42	61	83			
30	47	67	91			
32	51	74	100	131		
34	56	80	109	143		
36	61	87	118	155	196	
38	66	94	128	167	212	
40	70	101	138	180	229	280
42		109	148	193	244	299
44		117	159	207	261	320
46			170	222	277	340
48				236	293	361
50					310	382

Table 3

QUANTITY OF SILAGE REQUIRED AND ECONOMICAL DIAMETER OF SILO FOR THE DAIRY HERD

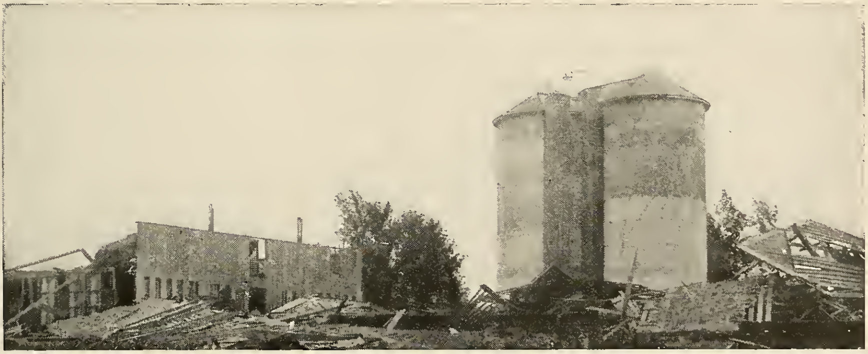
Number of Dairy Cows in Herd	Feed for 180 Days			Feed for 240 Days		
	Estimated Tonnage of Silage Consumed	Size of Silo		Estimated Tonnage of Silage Consumed	Size of Silo	
		Diameter	Height		Diameter	Height
	Tons	Feet	Feet	Tons	Feet	Feet
13	47	10	30	63	10	36
15	54	10	33	72	10	40
20	72	12	32	96	12	39
25	90	12	37	123	14	37
30	108	14	34	144	14	42
35	126	14	38	168	16	37
40	144	16	35	192	16	42
45	162	16	37	216	18	39
50	180	16	40	240	18	42
60	216	18	39	288	20	41
70	252	18	41	336	20	46

Monolithic concrete silos can be readily duplicated by using sliding metal forms.

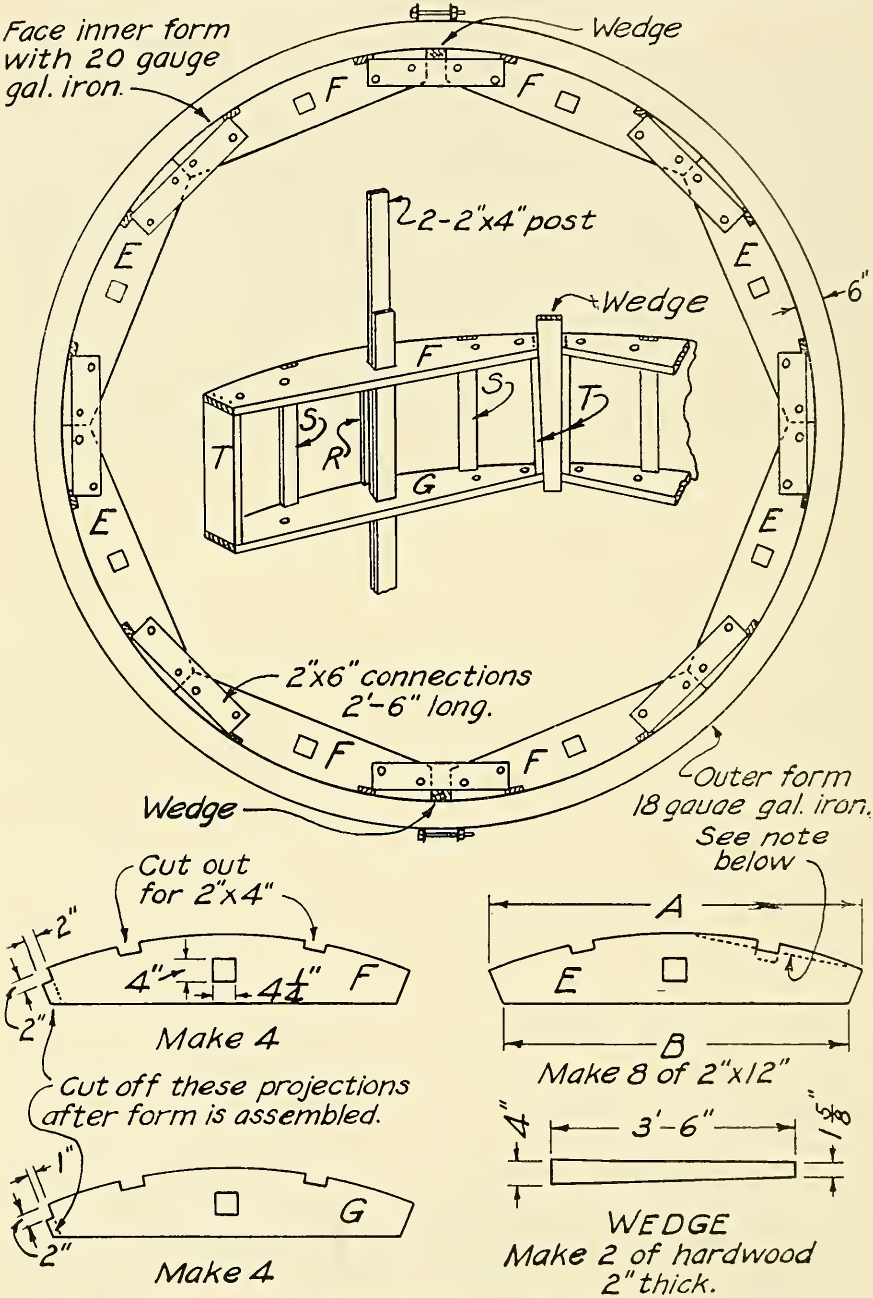
Monolithic Silos

How to Get the Silo Built

Where the services of a reliable concrete silo contractor can be secured, it is generally desirable to have the silo built by him under contract. In a great many cases the actual cost of a silo built under contract in this way is no greater than it would be if the owner built it himself. In the absence of a good contractor the farmer may build his own concrete silo if he can secure a good foreman for the job or if he is competent to supervise the work himself, but no details of the work as described in following pages must be slighted. Sometimes where several silos are to be built in one neighborhood a saving can be made if the intending builders will cooperate in making home-made forms that each may use. It may even prove a good investment for them to buy the regular commercial metal forms because distributing the total cost among

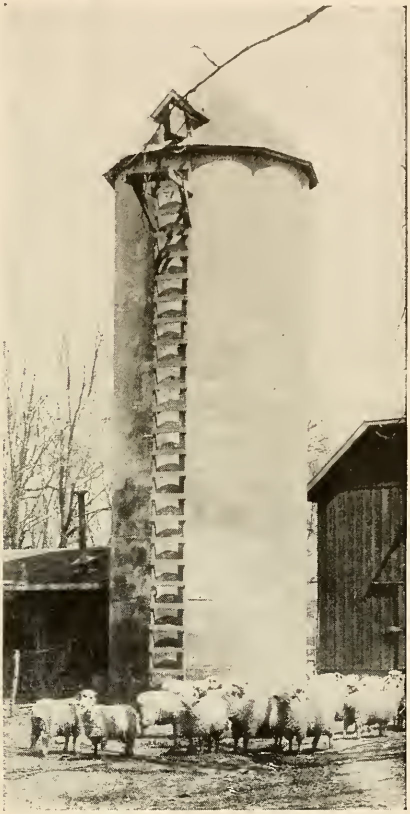


Monolithic concrete silos will withstand windstorms as proved by these twin silos on a Georgetown, Ky., farm in the cyclone of July, 1915, which destroyed all other farm buildings in its path.


Face inner form with 20 gauge gal. iron.
Wedge
F
F
F
F
E
E
E
E
2-2"x4" post
Wedge
F
S
S
T
T
R
G
6"
2"x6" connections 2'-6" long.
Outer form 18 gauge gal. iron.
Wedge
See note below
Cut out for 2"x4"
2"
2"
4"
4¼"
F
Make 4
Cut off these projections after form is assembled.
1"
2"
G
Make 4
A
E
B
Make 8 of 2"x12"
4"
3'-6"
1⅝"
WEDGE
Make 2 of hardwood 2" thick.

Details of silo forms that can be made on any farm.—NOTE—If intermittent doors are to be used trim two ribs "E" on dotted line.

the several silos built will make the cost of forms for each silo low. As such forms can be used many times, they may be rented or sold to others for similar community use.

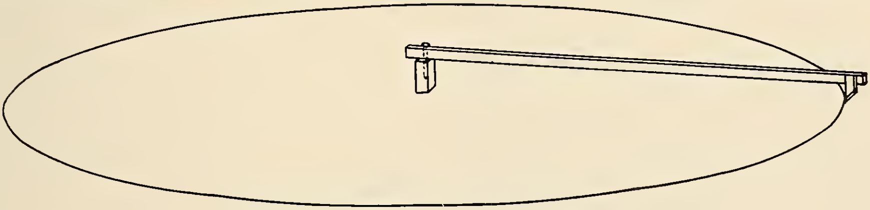


A silo insures a constant supply of feed when crops are poor.

Home-made Forms

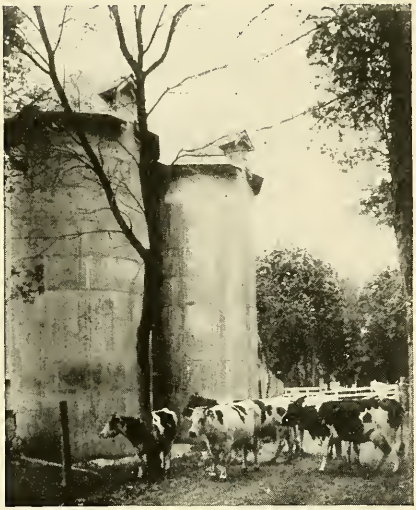
Home-made forms may conveniently be 36 inches deep, thus permitting the placing of 32 inches of concrete wall at each setting, the remaining 4 inches of depth being allowance for lap of forms on the concrete previously placed where forms are set for the next course.

To get the proper curve for the inner forms, the usual practice is to mark out a circle on a level floor, using a sweep similar to that which would be used to lay out the line for digging the foundation trench. The diameter of this circle is the same as the inside diameter of the silo to be built. Some details of construction for home-made silo forms are illustrated on page 6, which show various parts of an inside form. The sweep used to lay out the proper curve for the inner form also serves to mark the pattern for the ribs E, F, and G, shown on page 6. When the ribs have been sawed out, each of the sections, which make up the inner form, is built up by using 2 by 6-inch studding like the pieces T. Pieces S and R are made of 2 by 4's. Pieces S are set into the ribs, and pieces T and R are nailed between them. Care must be taken to build the sections so that they will assemble as shown, with openings for the wedges as indicated at opposite points on the form. If intermittent door openings are to be provided, it is a good plan to make a



Arrangement of sweep for laying out silo forms.

flat place 2 feet 4 inches wide on one section, so that the door form need not be curved. Square each section accurately and face with 20-gage galvanized sheet iron, nailed in place with 6-penny nails. Assemble the sections in the circle which has been drawn and bolt them together top and bottom with 2 by 6-inch strips, 2 feet 6 inches long. Forms and connections should be marked so they will always be assembled in exactly the same way. After the forms have been assembled the first time projections on the ends of ribs F and G are cut off. This will allow the forms to collapse when the wedges are removed.


When the cows come home the concrete silos bring contentment, greater milk production, greater milk checks.

The outer form is made of two sections of 18-gage galvanized sheet iron fitted with lugs for tightening and with hooks for raising as shown on page 9.

Dimensions of inner and outer form sections

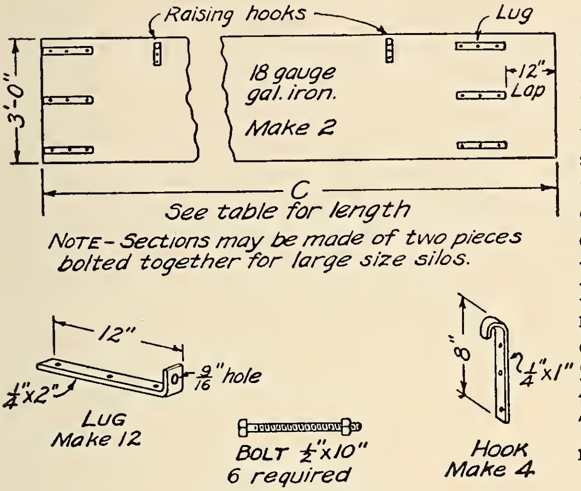
	Inner Form				Outer Form
Inside diameter of Silo	Number of Sections in Inner Form	Length A	Length B	20-Gauge Gal. Iron 36 in. wide, Length of Each Piece	18-Gauge Gal. Iron 36 in. wide, 2 Pcs. Length of Each Piece, C.
10 ft.	6	5′- 0″	4′- 7½″	5′-2¾″	18′- 3″
12 ft.	8	4′- 6¾″	4′- 1½″	4′-8½″	21′- 5″
14 ft.	8	5′- 4″	4′-11½″	5′-6″	24′- 7″
16 ft.	8	6′- 1″	5′- 9½″	6′-3″	27′- 9″
18 ft.	8	6′-10½″	6′- 7½″	7′-0¾″	30′-10½″
20 ft.	10	6′- 2″	5′-10″	6′-3″	34′- 0″

Material for 14-Foot Silo Form

5 pieces 2 by 12 by 16 feet, for ribs
1 piece 2 by 12 by 6 feet, for ribs
4 pieces 2 by 6 by 12 feet, for studding
6 pieces 2 by 4 by 12 feet, for studding
4 pieces 2 by 6 by 10 feet, for connections
3 pieces 2 by 6 by 8 feet, for continuous door form
2 pieces 2 by 2 by 8 feet, for continuous door form
64 pieces ½ by 4½ inch carriage bolts
2 pieces 18 gage galvanized iron 3 feet wide, 24 feet 7 inches long
8 pieces 20 gage galvanized iron 3 feet wide, 5 feet 6 inches long
Nails, rivets, lugs, hooks, wedges, etc.

Doorways

Concrete silos may be equipped with two types of doorways—intermittent and continuous. As either type is satisfactory, choice is largely a matter of individual preference.



Details of outer forms.

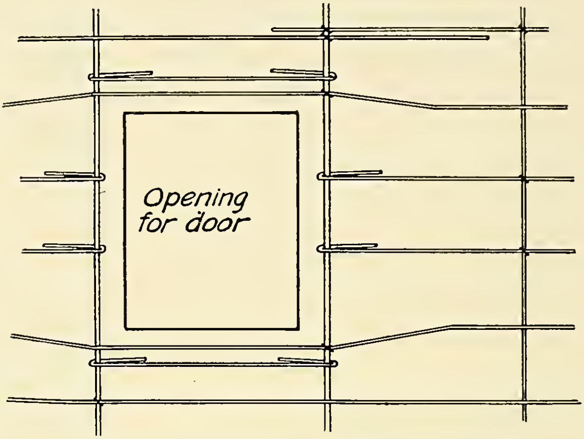
The form to provide for intermittent doorway openings is simple. It consists of 2 by 6-inch lumber, nailed together to form a frame like shown on page 11. This frame is tapered ¼ inch on all sides to permit easy removal from the wall after concrete has hardened. To form the necessary recesses for the door in concrete, 2 by 2-inch pieces are nailed to the frame as shown. This form is used in alternate settings of the wall forms, thus spacing the openings about 2½ feet apart.

Form for the continuous doorway opening is shown on page 11. This is made of two pieces of 2 by 6-inch lumber 8 feet long. Holes 1⅛ inches in diameter are bored 2 feet apart in each piece, with centers 2 inches from the edge. Vertical pieces are then ripped along a line crossing the center of the holes, thus dividing the form into an inner and an outer section to permit easy removal. Slightly beveled 2 by 2-inch pieces are nailed to the inside frame. When using this form, 1-inch doorway rods are set in the holes. Cleats and spacing boards are then lightly nailed in place to hold the uprights the proper distance apart.

Proper arrangement of reinforcement at doorway openings is shown on page 10. Vertical rods at the sides of the doorways should be ½ inch in diameter for silos smaller than 100 tons capacity and ⅝ inch in diameter for silos of greater capacity. If intermittent

A concrete silo, 108 feet high, on a Salona, Pa., farm.

doors are used, additional rods equal to the area of the horizontal rods which are necessarily omitted at the door openings are placed above and below the door.

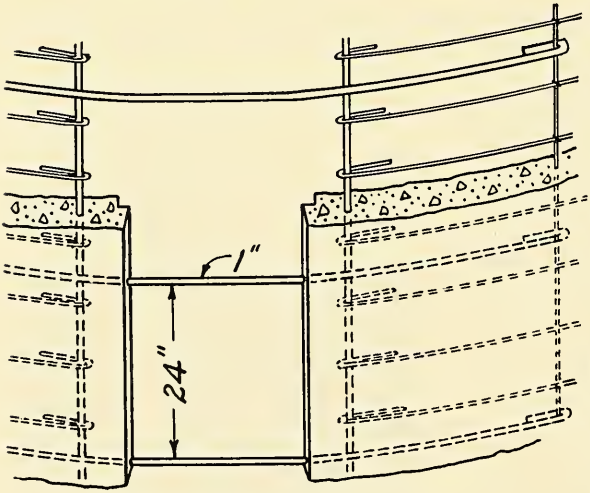


Arrangement of reinforcement around intermittent doorway opening.

Doors both for the intermittent and continuous types of doorway openings are made of two thicknesses of matched flooring, nailed to each other at right angles, with a layer of tar paper between. Three feet is a convenient length for continuous doors.

Reinforcement

When silage has thoroughly settled in a silo it exerts considerable bursting pressure on the walls. This pressure increases toward the bottom of the silo and therefore more reinforcement must be used at the bottom than near the top. Round or square steel rods or some form of woven wire mesh is used as "hoops" in the concrete, embedded at the center of the wall where the metal will be prevented from rusting. Ordinary woven wire fencing should not be used instead of the steel mesh fabric made specially for reinforcing concrete.

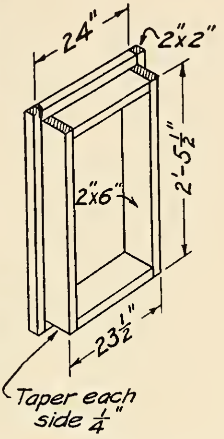


Reinforcement for continuous doorway opening.

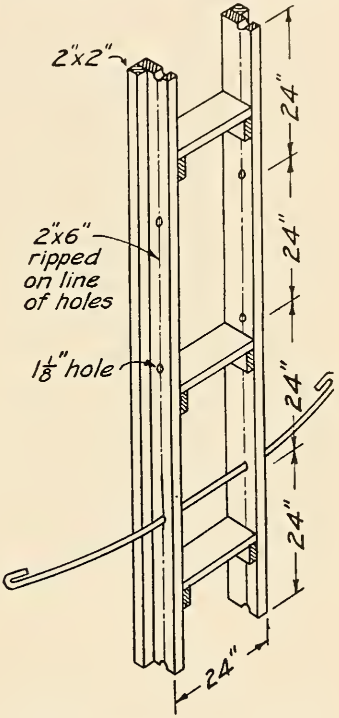
After the size of the silo is decided upon, the type and quantity of reinforcement should be determined and ordered so that there will be no delay due to waiting for it when all other arrangements preparatory to starting construction have been completed.

The amount of horizontal reinforcement required when rods are used is shown in Table 4.

To illustrate the method of determining the amount of reinforcement, assume a silo 14 feet inside diameter and 40 feet high as an example. For an inside diameter of 14 feet the table specifies ½-inch round rods. The column at the extreme left of the table gives the distance from the top of the silo for intervals of 5 feet. As the silo is 40 feet high, run down the column to the line "35 to 40 feet," then across to the column under "14-foot diameter." This shows the spacing as 12 inches, which means that there must be a horizontal ring of ½-inch steel every 12 inches. This spacing applies to the first 5 feet above the floor. For the next 5 feet the spacing changes to 14 inches. Spacing becomes greater as the top of the silo is approached and can be found by simply following the 14-foot column to the top. This method of determining the horizontal reinforcement applies to all sizes and heights of silos.



Form for intermittent doorway opening.



Form for continuous doorway opening.

Table 4

SPACING OF HORIZONTAL REINFORCING RODS FOR SILOS OF VARIOUS INSIDE DIAMETERS

Distance in Feet Down from Top of Silo	10-foot Diameter ⅜-inch Round Rods	12-foot Diameter ⅜-inch Round Rods*	14-foot Diameter ½-inch Round Rods*	16-foot Diameter ½-inch Round Rods*	18-foot Diameter ½-inch Round Rods*	20-foot Diameter ½-inch Round Rods*
	Inch	Inch	Inch	Inch	Inch	Inch
Top 5 ft.	24	24	24	24	24	24
5 to 10	24	24	24	24	24	24
10 to 15	24	18	24	24	24	24
15 to 20	18	16	24	18	18	16
20 to 25	16	12	18	16	14	14
25 to 30	14	10	16	14	12	12
30 to 35	12	9	14	12	10	10
35 to 40	10	8	12	10	9	8
40 to 45	9	7	11	9	8	7½
45 to 50	8	6½	10	8½	7½	7

*If square rods are used increase spacing 30 per cent, but in no case should spacing be greater than 24 inches.

Vertical reinforcement is needed in all monolithic concrete silos. This consists of 3/8 or 1/2-inch steel rods spaced 30 inches apart, regardless of the size of the silo. Square twisted rods are preferable for this as their surface permits wiring the horizontal rods to them more securely.

A very satisfactory type of wire mesh reinforcement is known as "triangle mesh." This comes in 36-inch widths, thus allowing a lap of 4 inches for each ring when using 3-foot forms. Table 5 gives the size and quantities of this mesh to use for silos of various sizes.

Table 5

TRIANGLE MESH REINFORCEMENT

Distance in Feet from Top	Inside Diameter of Silo											
	10 Feet		12 Feet		14 Feet		16 Feet		18 Feet		20 Feet	
	Layers	Style No.	Layers	Style No.	Layers	Style No.	Layers	Style No.	Layers	Style No.	Layers	Style No.
0 to 15	1	093	1	093	1	093	1	093	1	093	1	093
15 to 18	1	093	1	093	1	093	1	093	1	093	1	126
18 to 21	1	093	1	093	1	093	1	126	1	126	1	126
21 to 24	1	093	1	093	1	126	1	126	1	126	2	093
24 to 27	1	093	1	093	1	126	1	126	2	093	2	093
27 to 30	1	093	1	126	1	126	2	093	2	093	2	093
30 to 33	1	093	1	126	2	093	2	093	2	093	1 each	093& 126
33 to 36	1	126	1	126	2	093	2	093	1 each	093& 126	1 each	093& 126
36 to 39	1	126	2	093	2	093	2	093	1 each	093& 126	2	126
39 to 42	1	126	2	093	2	093	1 each	093 & 126	2	126	2	126
42 to 45	1	126	2	093	1 each	093 & 126	1 each	093 & 126	2	126	2	146
45 to 48	2	093	2	093	1 each	093 & 126	2	126	2	146	2	146
48 to 50	2	093	2	093	1 each	093 & 126	2	126	2	146	2	146

NOTE: Style number 093 has number 6 wires spaced 4 inches apart
Style number 126 has number 4 wires spaced 4 inches apart
Style number 146 has number 3 wires spaced 4 inches apart

Concrete Materials

Materials required for concrete are portland cement, sand, pebbles or crushed stone and water.

Any standard brand of portland cement may be used.

Sand and pebbles or broken stone are called aggregates. Sand is known as fine aggregate; pebbles or broken stone as coarse aggregate.

Sand should be clean and well graded. By well graded is meant that the grains should vary in size from fine up to a diameter of 1/4-inch for the largest particles. The sand must be free from vegetable or other foreign matter. If it is dirty it should be washed before being used.

Either pebbles screened from the ordinary gravel bank or crushed rock may be used for coarse aggregate. If pebbles are used they must be clean and free from any coating of clay or other foreign matter and should range in size from 1/4 to 1 1/2 inches. If crushed stone is used it should have the same grading as the pebbles and should be free from dust. Bank-run gravel, which means the natural mixture of sand and pebbles just as taken from the gravel bank, should not be used until screened so that the sand and pebbles may be correctly reproportioned. There are such variations in the relative volumes of sand and pebbles in each gravel bank that concrete made from such material will not be uniform in strength.

Water used for concrete should be clean and free from acids, oils or alkali. Any water that is fit to drink is suitable for a concrete mixture.

Twin silos increase storage capacity at reasonable cost.

Concrete of three different proportions is used in building monolithic silos. A 1:2½:5 mixture is satisfactory for the foundation and the floor. This means 1 sack or 1 cubic foot of portland cement, 2½ cubic feet of sand and 5 cubic feet of pebbles or broken stone. For the walls a 1:2½:4 mixture is used. For the roof use a 1:2:3 mixture. All the materials are proportioned by volume, a sack of cement being considered 1 cubic foot.

Table 6

QUANTITY OF CONCRETE MATERIALS FOR MONOLITHIC SILOS OF VARIOUS DIAMETERS

These figures include footings and floor, but not roof. Walls 6 inches thick. Continuous doors 2 feet wide. Figures are for sacks of cement and cubic yards of sand and pebbles:

Inside Diameter Feet	For Silo 30 Feet High			For Each Additional 5 Feet in Height		
	Cement Sacks	Sand Cu. Yd.	Pebbles or Stone Cu. Yd.	Cement Sacks	Sand Cu. Yd.	Pebbles or Stone Cu. Yd.
10	116	11	18	16.0	1.5	2.4
12	140	13	21.5	19.2	1.8	2.9
14	164	15	25	22.5	2.1	3.4
16	188	17.3	28.7	25.7	2.4	3.8
18	212	19.6	32.6	29.0	2.7	4.3
20	236	22	36.5	32.3	3.0	4.8

Mixing Concrete by Hand

If the concrete is mixed by hand, a watertight mixing platform 8 by 12 feet is needed. This should preferably be of 2-inch planks tongued and grooved, so that tight joints will be formed to prevent cement from being carried away by leakage of mixing water. Three sides of the platform should have a strip nailed along the edge, extending 2 inches above the top of the platform, to prevent materials from being washed or shoveled off while mixing.

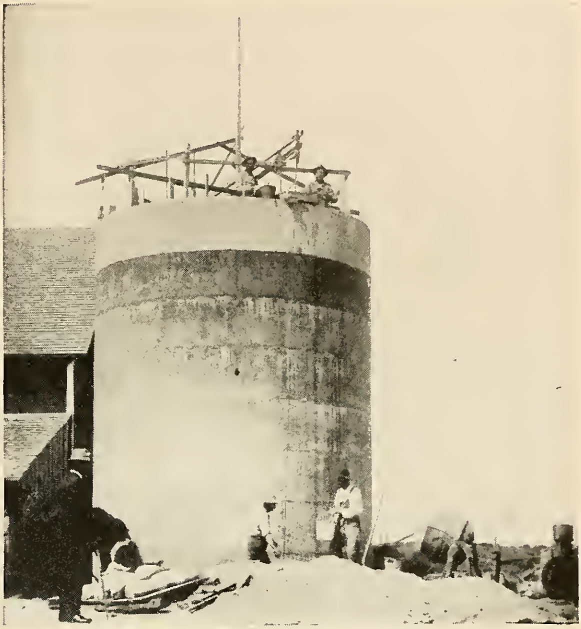
A measuring box is necessary so that sand and pebbles or broken stone can be accurately measured for correct proportioning. Such a device is really a bottomless box and may be made of one or four cubic feet capacity. In the latter case, marks should be made at proper levels on the inside to indicate capacities of 1 and 2½ cubic feet. When used, the measuring box is set on the mixing platform and, after the required amount of sand has been measured, the box is raised and the sand spread about in an even layer on the platform. Next the cement, which need not be measured, as each sack is considered as 1 cubic foot, is spread in an even layer on top of the sand. Square-pointed shovels are used to turn the cement and sand two or three times or more, if necessary, until the streaks of brown and gray have merged unto a uniform color, indicating a thorough mixing of the two materials.

Filling time always finds the concrete silo in good condition.

Pebbles or broken stone, first thoroughly wet, are then measured and spread in a layer on top of the cement and sand and all of the materials again mixed by turning with shovels. Then a depression or hollow is made in the center of the pile and water added gently, preferably by a spray from a hose. As water is being added, two or more men turn the materials with square-pointed shovels until the cement, sand and pebbles have been thoroughly and uniformly mixed and the desired consistency obtained.

(Wheelbarrows are made of varying capacities to be used for measuring sand and broken stone. Measuring wheelbarrows are generally used when concrete is mixed by machine because the materials can readily be dumped from wheelbarrows into the mixing hopper or loading skip, otherwise a measuring box of 1 cubic foot capacity is set in an ordinary wheelbarrow and filled in the usual way.)

Mixing by Machine



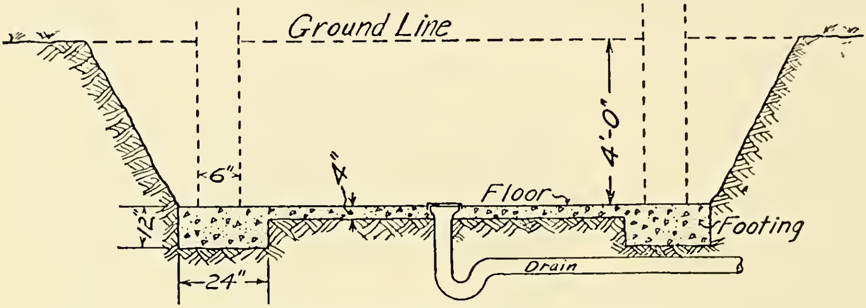
Concrete silo being built with home-made forms like those described on pages 6 to 11.

Concrete is more readily and uniformly mixed by machine and the labor of hand mixing is thereby avoided. Many excellent small power operated mixers are now on the market, the power being supplied by a gasoline engine, usually a part of the entire outfit, although mixers can be obtained without an engine, equipped so that the farmer may use an engine which he already possesses. Some very small sizes of mixers are geared to a large crank which is turned by one or two laborers. Machine mixing should continue for at least one minute after all materials have been placed in the mixer and concrete should be deposited in the forms immediately after mixing, but in no case should the maximum time allowed to lapse between mixing and placing be more than thirty minutes.

Foundations

To lay out the area to be excavated for the foundation, use a sweep similar to that shown on page 7. If the ground is firm so that the earth walls of the excavation will stand without caving, thus making an outer form for the foundation wall unnecessary, the circle described by the sweep should be the same diameter as the outside diameter of the silo. If, however, the ground will not stand up, thus making it necessary to use outside forms, the circle should be described considerably larger than the diameter of the silo so that the excavation may be sloped to give ample room for setting up outside forms. The trench for the footing extends 8 inches below the excavation proper, and is 2 feet wide. A foundation pit in loose ground where outside forms for the concrete would be necessary is shown on page 16.

A concrete silo is usually built so that the floor will be about four or five feet below ground level. This insures that the bottom of the foundation will be below frost line. The height of the silo above ground is also reduced by this much, thus lessening the distance through which scaffolding and other material must be raised. The depth of the silo below ground is seldom over 5 feet as it would be difficult to throw out the last of the silage from a greater depth.



Foundation pit for concrete silo, showing floor and drain.

It is a good plan to provide for a drain at the center of the floor, connected to a line of drain tile to carry off excess liquid which, if allowed to accumulate in the silo, would greatly increase the pressure on the walls near the bottom. Where such a drain is installed, it must be covered with a screen at floor level to prevent silage from entering and choking the outlet, and also should be fitted with a bell or goose neck trap to prevent air from entering the silo.

Floor and footing are placed in one operation. If the ground on which the silo is built is not firm, the footings should be widened to 4 feet and reinforced with 3/8-inch square rods laid 8 inches apart across the footing and about 1¼ inches from the bottom.

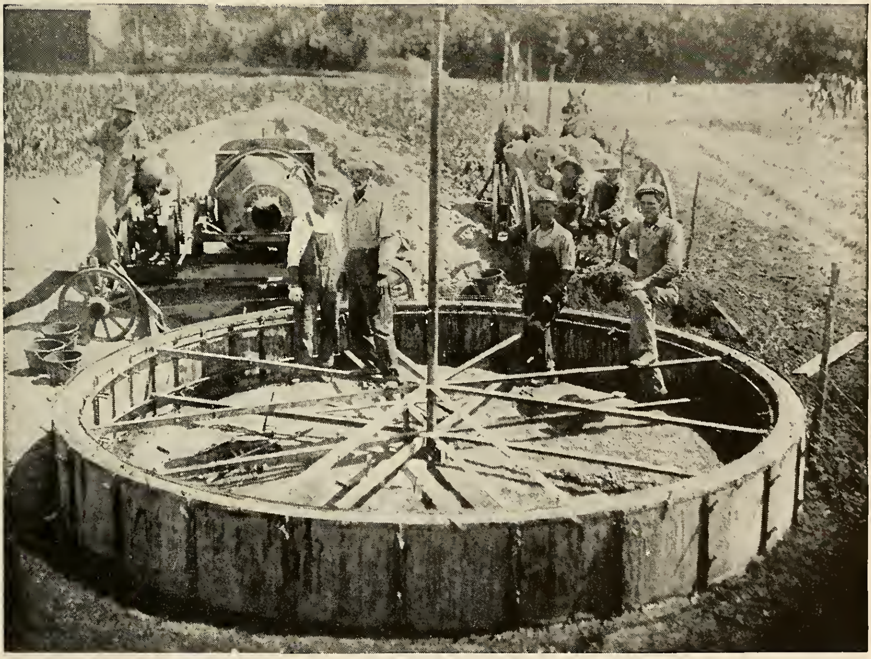
As the concrete is being placed for the footing, lengths of 3/8-inch or ½-inch square twisted steel rods are set vertically in the footing, 30 inches apart. These form vertical reinforcing for the silo wall and are placed in the center of the footing, so that they will project upward into the center of the wall. After floor and footing have been in place 24 hours, construction of the silo walls may begin. Before these are started, clean the top of the footing, removing all loose material. Then apply a paint of cement and water mixed to the consistency of cream to help secure a good bond and tight joint where wall and footing join.

Building the Silo Walls

There are seven operations connected with building the walls: (1) The forms must be set; (2) Reinforcement must be placed in proper position; (3) Concrete mixed and placed; (4) Outside form released, raised and reset; (5) Reinforcement placed for the next course; (6) Inside form released, raised and reset; (7) Provision must be made for openings in the walls for doors and the details for the chute arranged.

An outside form will not be necessary for that portion of the wall below ground if the earth is firm enough to stand without caving, otherwise both inner and outer forms will be required.

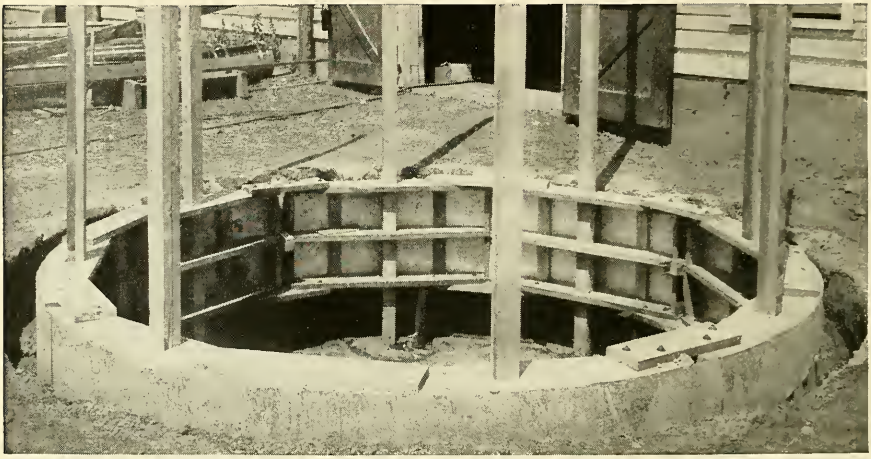
Horizontal reinforcement should be wired to the vertical rods already set when concrete was placed for the foundation and footing. Ordinary No. 12 or No. 14 gage wire will serve to tie vertical and horizontal rods together where they intersect. Where it is necessary to splice horizontal reinforcing, ⅜-inch rods should be lapped 18 inches and ½-inch rods 2½ feet. For vertical reinforcing a lap of 18 inches will be sufficient. The first ring of horizontal rods should be placed 2½ inches above the silo footing and from this rod upward spacing should be as specified in Table 4. After the horizontal reinforcement has been properly spaced and securely wired to the vertical rods to hold it in proper position, the inside form may be set and carefully leveled, then 1:2½:4 concrete as already specified is placed in the forms, care being taken, if no outer form is used, not to allow earth to fall into the concrete while placing it. Concrete should be of a consistency that will permit it to be readily settled in the forms and around reinforcement.



Metal forms erected on completed floor—ready to build the silo.

After the first course of concrete has been placed and while the inner form is still in position on the footing, double 2 by 4 uprights or plumb legs are erected through the square holes provided in the inner form. These uprights guide and support the inner form and therefore should rest solidly on the floor of the silo and be carefully plumbed. They should also be plumbed after each lift to insure that the walls will be truly vertical.

Each day the outside form is raised to within 4 inches of the top of concrete last placed, the vertical rods spliced if necessary, and horizontal rods attached to them for the next course. The inner form is then raised, leveled and plumbed, and concrete placed to fill the forms for this course. To keep inner and outer forms the proper distance apart, a number of spacers 6 inches long may be used. These can be of wood and should be removed as concrete is placed up to them.

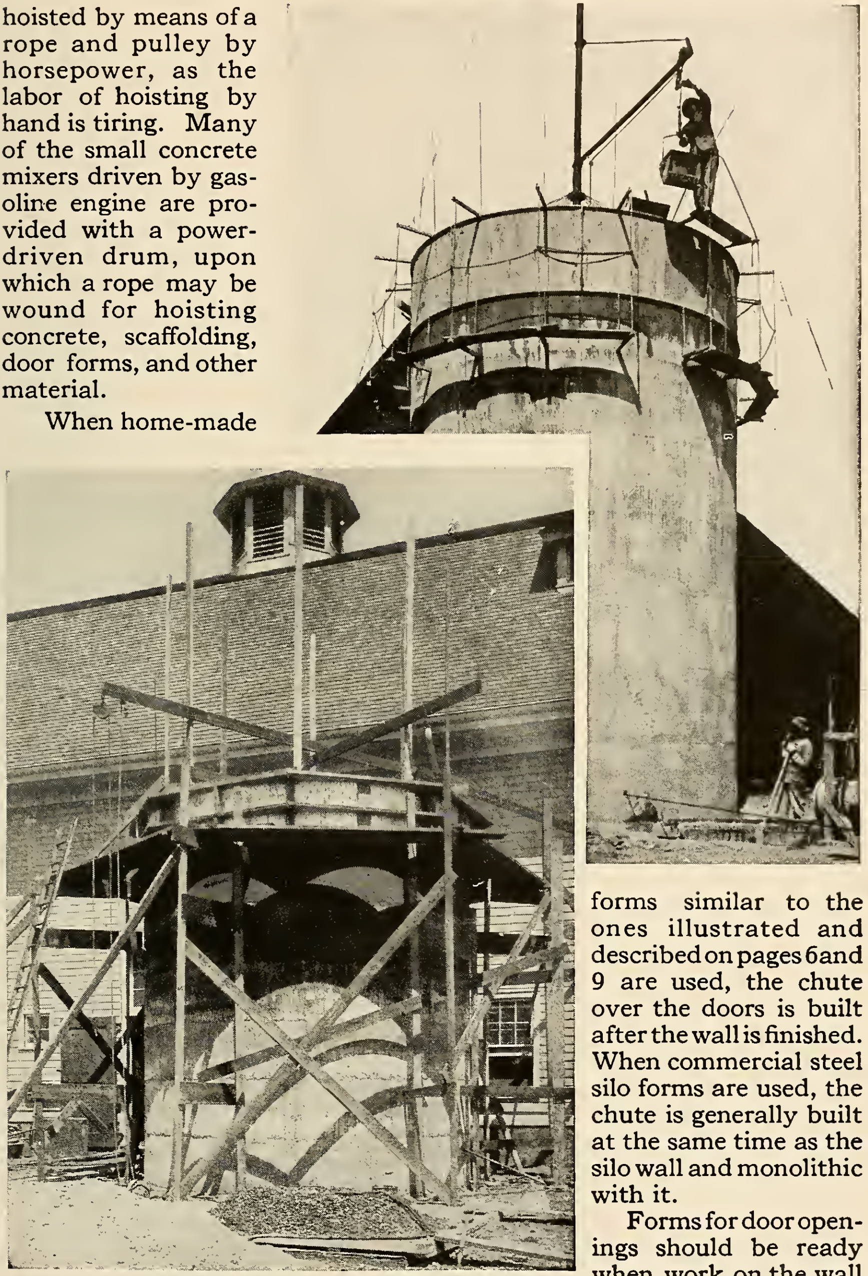


Home-made forms with upright guides in place on completed foundation.

Concrete must be well settled into the forms in order to secure a smooth, dense wall. A spading tool made from a piece of thin board beveled at the lower end and shaped to have a handle at the other is worked down between concrete and form face to force pebbles or broken stones back from the form, allowing mortar to come against the form and produce a dense, smooth surface. The inside of the wall especially should be given particular attention in this respect to prevent the formation of irregularities or offsetting projections where the courses join.

Before considering a day's work finished, the top surface of the concrete in the forms should be roughened to provide a good bond for the next course, and just before placing concrete for the next course the top of the wall should be washed with water and painted with a cement grout prepared by mixing portland cement and water to the consistency of thick cream.

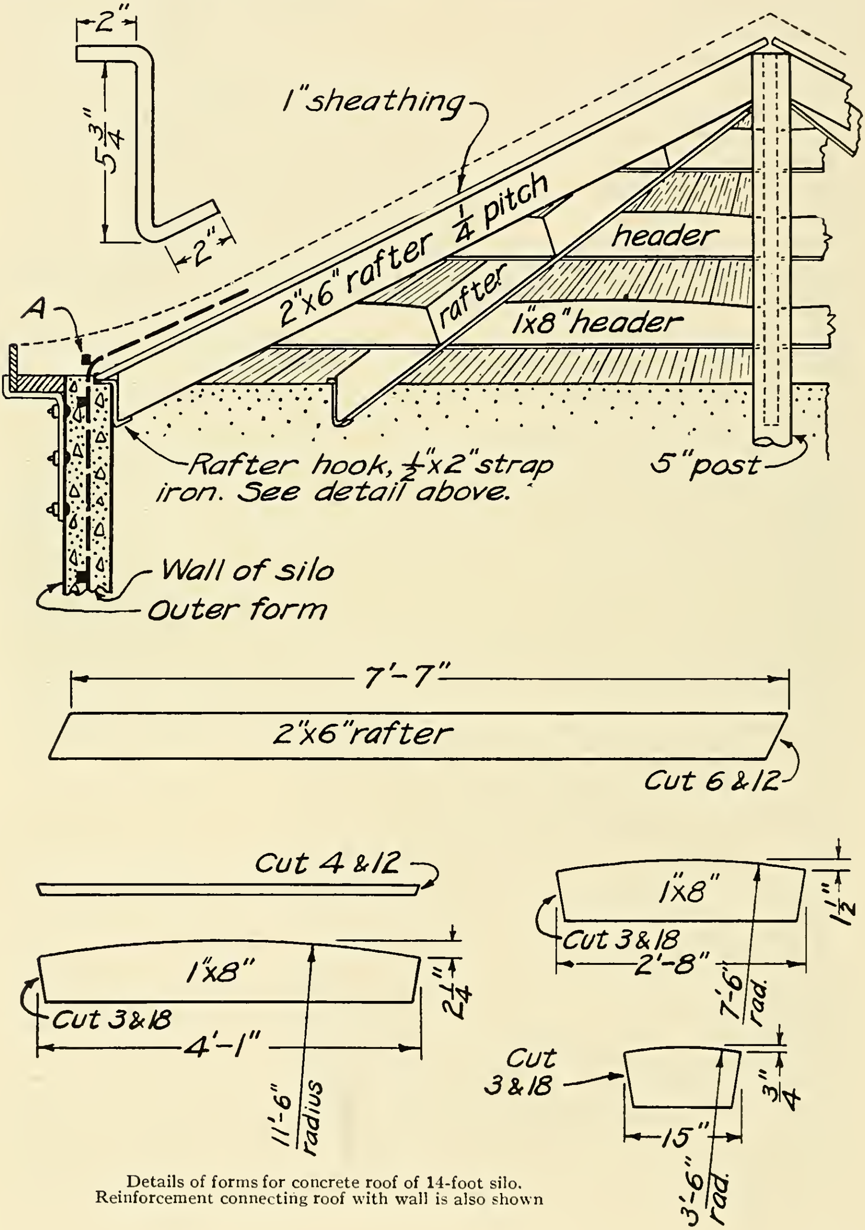
Concrete for the upper courses of the wall can be raised in large buckets or receptacles designed especially for this purpose. It should be hoisted by means of a rope and pulley by horsepower, as the labor of hoisting by hand is tiring. Many of the small concrete mixers driven by gasoline engine are provided with a power-driven drum, upon which a rope may be wound for hoisting concrete, scaffolding, door forms, and other material.



Monolithic concrete silos under construction, upper picture with commercial, lower with homemade forms.

When home-made forms similar to the ones illustrated and described on pages 6 and 9 are used, the chute over the doors is built after the wall is finished. When commercial steel silo forms are used, the chute is generally built at the same time as the silo wall and monolithic with it.

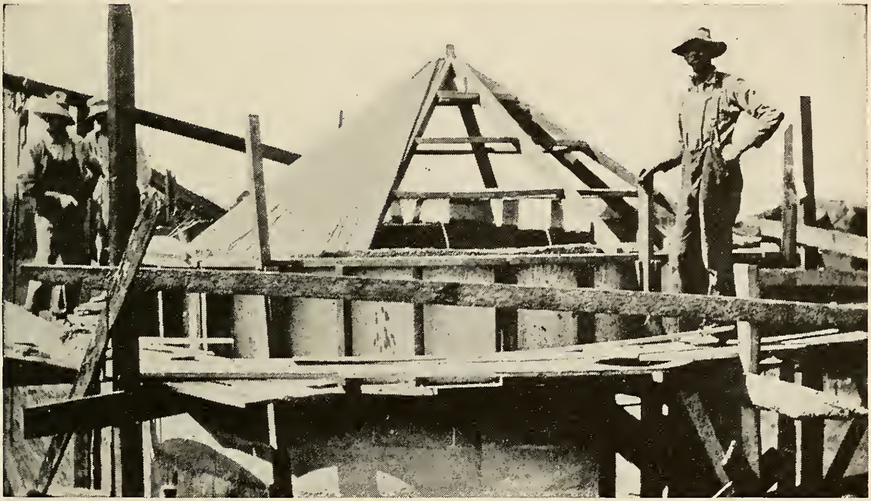
Forms for door openings should be ready when work on the wall is started. It is a good plan to oil or soap the door forms so as to make their removal easy. Extra care must be used to work the fresh concrete around the door openings so as to secure a smooth surface finish and to insure a close airtight fit between door and concrete.



Details of forms for concrete roof of 14-foot silo. Reinforcement connecting roof with wall is also shown

Constant attention must be given to alignment of forms so that a smooth wall of good appearance will result. If, after raising forms, stone pockets or similar holes appear on the surface due to carelessness in spading the concrete, or because of water carrying cement having leaked through the forms, these holes or pockets should at once be patched with a cement mortar made by mixing 1 part cement and 2½ parts of fine sand worked into the opening with a trowel.

As rapidly as forms are raised, the inside wall face should be painted with a wash of cement and water mixed to creamy consistency. This should be applied while the wall is still moist. Only a thin coat is required.



Wall completed, forms being placed for the concrete roof.

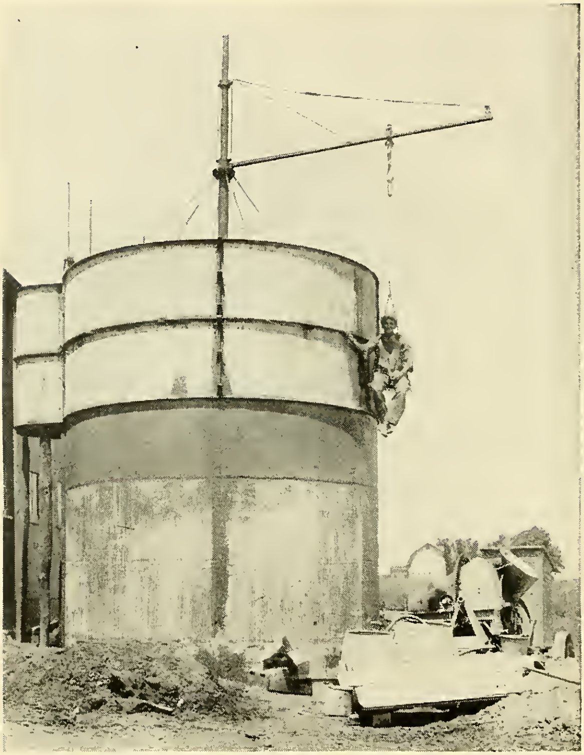
The outside of the silo may be improved in appearance by the same treatment, but this need not be done until all of the work has been completed. If the wall has dried out, it should be thoroughly drenched with water before the wash is applied. This will conceal any of the patches which may have been made and will give the exterior of the silo a uniform color.

The Concrete Roof

No concrete silo is complete without a concrete roof. A concrete roof requires no maintenance and makes the structure fireproof and permanent.

From the standpoint of appearance, a cornice is desirable. This may be made as shown on page 20. Brackets of ¼-inch by 2-inch strap iron are bolted to the top of the outer form at intervals of about 5 feet. The bottom of the cornice mold is made of short pieces of 2 by 6-inch lumber cut to the curvature of the silo. The side of the mold is a 1 by 6-inch piece nailed to the bottom piece and bent to the curve of the cornice.

When finishing the top of the silo wall, an offset 2 inches wide and 1 inch deep should be left on the inside to support the lower end of the form boards. Remove the inner wall forms over the top of the silo and build a framework of 8 rafters and 8 sets of headers, as shown on page 20. The lower ends of opposite rafters should be tied together with 1 by 4-inch boards. This framework is covered with 1 by 12-inch boards cut diagonally and laid with the wide ends at the base of the roof. A frame for the filling window should also be made similar to the intermittent door frame except that 1-inch lumber may be used. This opening should be of a size suited to receive a frame containing four 10 by 12-inch lights, which will require an opening 2 feet by 2 feet 5 inches.



Commercial metal forms insure a smooth wall surface and a true, uniform silo cross-section.

Place reinforcement in position and cover the entire form, including the cornice form, with strips of woven wire mesh and add rods according to the size of the silo. For silos 14 feet in diameter and smaller, a ½-inch round rod with ends securely hooked together is placed around the base of the roof, as at A, on page 20. For silos larger than 14 feet in diameter, two such rods should be used. The vertical rods projecting from the wall are bent over into the roof. A ⅜-inch or ½-inch rod is placed entirely around the opening for the filling window.

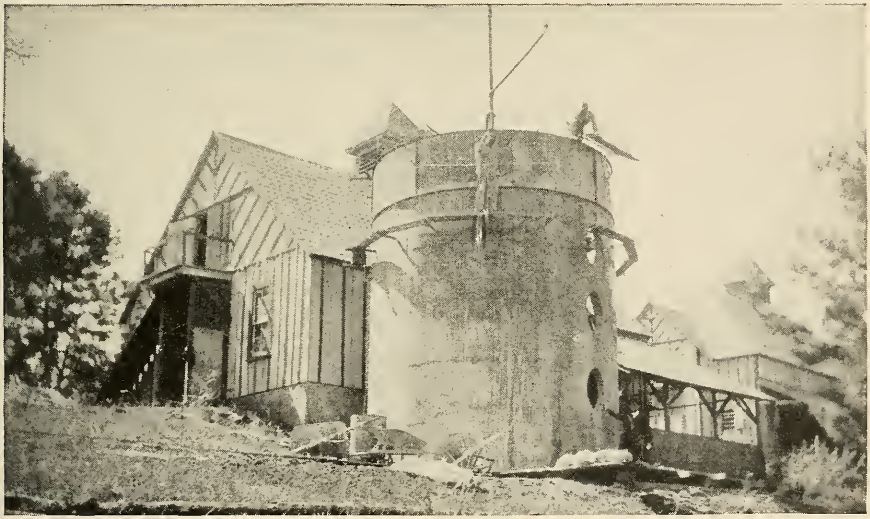
For the roof a 1:2:3 concrete should be used with just enough water in the mixture so that the concrete may be worked into place easily, yet will not flow in the form because of the slant of the roof. An average thickness of 3 inches of concrete is sufficient for the roof, this being increased slightly at the eaves and decreased at the peak.

The Silo Chute

The chute is fastened to the silo wall to enclose the doorway. It serves also as a protection against the weather and keeps the silage from scattering about when thrown down for feeding. Chutes may be built of wood, sheet metal or concrete. The last is best for a concrete silo and gives complete protection to the doors in case of fire. A concrete chute 2½ feet square inside is of convenient size.

Commercial silo forms provide for building concrete chutes monolithic with the walls. Where home-made silo forms are used the chute is most easily built after the walls have been finished. To provide for this, ⅜-inch rods 2 feet long are placed in the wall as it is built, at each side of the doorway, and every 2 feet in the height of the silo. They are hooked around the wall reinforcement and are bent up so they can be laid next to the outer form. When the form is removed these rods are at the surface of the concrete and can then be bent straight into the chute and tied securely to the silo.

In building a concrete chute, wooden forms may be used. Concrete is reinforced with ⅜-inch rods 2 feet apart horizontally and vertically.



Rapid construction of monolithic concrete silos becomes possible with metal forms.

Ladders

In silos having continuous doors, the heavy steel bars extending across the doors usually serve as ladder rungs. It is better, however, to provide a ladder on the inside of the chute. In a monolithic concrete chute, this can be done by setting U-shaped rungs of ½-inch steel bars in holes left in the concrete. These holes are formed by tapered wooden plugs placed in the chute forms.

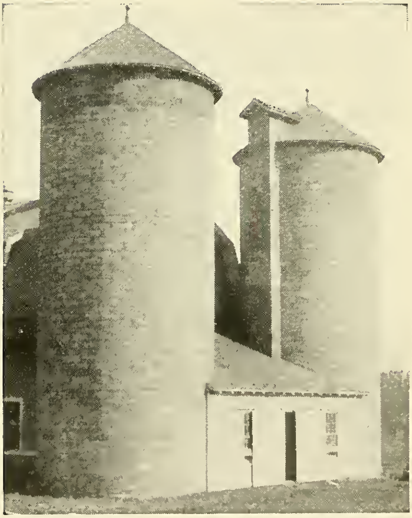
Commercial Silo Forms

Commercial silo forms are built of metal, are rigid, easily handled, serve for repeated use if properly taken care of and, in general, insure the best-looking silo. They are therefore preferable to home-made forms. Practically all commercial forms consist of rigid sheet metal, stiffened with angle iron and made in sections, each section being part of the circumference of the silo. They are provided with clamps for holding them firmly together, and, owing to the accuracy with which sections may be assembled, result in a smooth, even silo wall.

Commercial silo forms usually include scaffolds, raising jacks and derricks for elevating the concrete. They make it possible to build silos quickly with the minimum amount of labor. If several silos are to be built in a neighborhood where the services of a contractor are not available, interested farmers may club together and buy their forms, thus making the cost of forms for each silo low, but as has already been said elsewhere in this booklet the best way is to employ a regular silo contractor with proper commercial equipment.

To obtain the best results care must be taken in selecting the aggregates, in proportioning, mixing and placing the concrete, and in protecting the newly-placed concrete until thoroughly hardened.

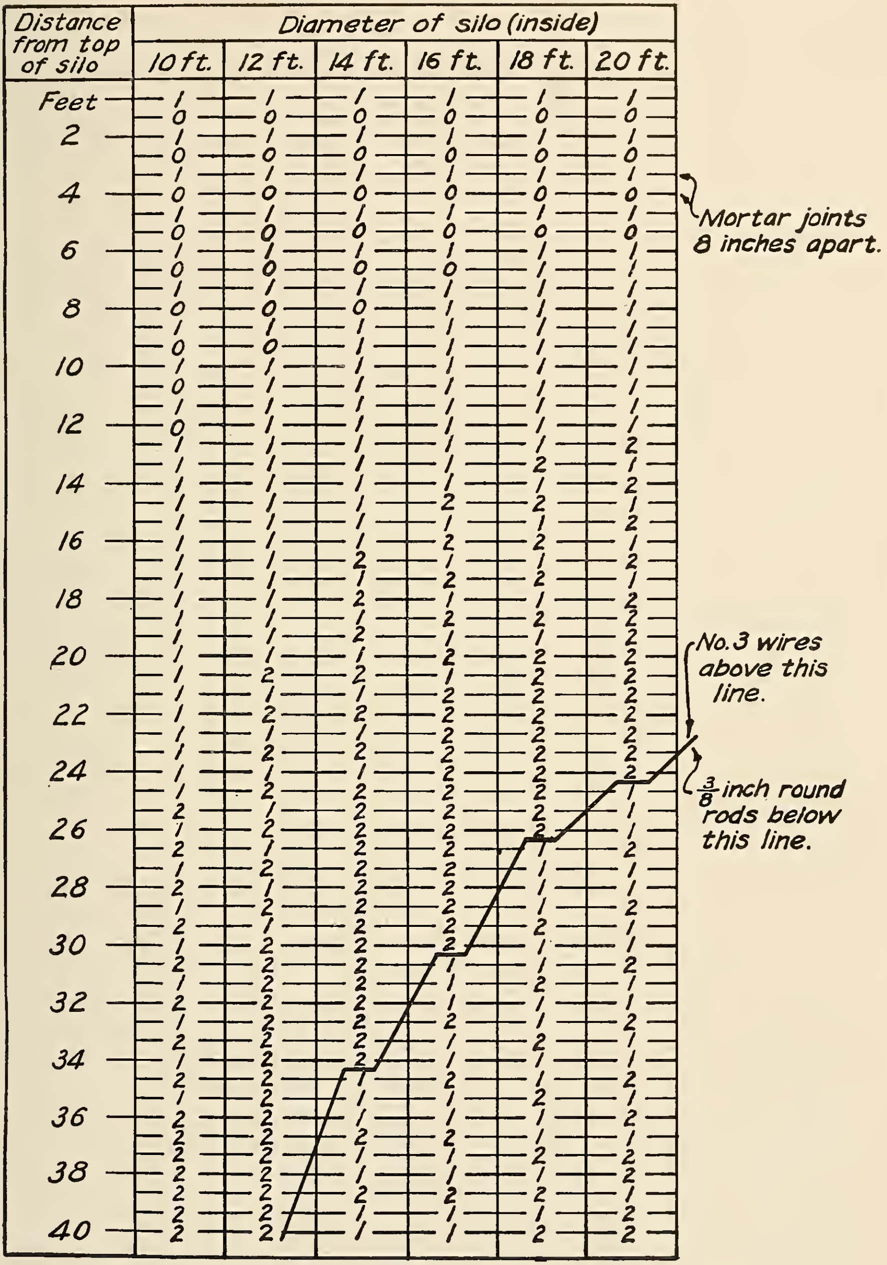
Concrete Block Silos



Concrete block silos are most readily adapted to erection by home labor.

Principal Features

Concrete block silos are pleasing in appearance and, if properly built, give full satisfaction. The farmer who wants a concrete silo, yet wishes to avoid building the forms necessary for a monolithic silo, or who cannot readily avail himself of commercial silo forms, will find the block type of silo especially practical. Silo block are curved so that when laid up a course conforms to the curvature of the silo. Silo block may be home-made in simple machine molds, or may be purchased from a nearby cement products plant. The latter is preferable since such plants are usually better equipped to observe all requirements of manufacture than is the farmer. One form of concrete block for silos has air spaces and is provided with a groove in the top bed to take steel reinforcement. Another type is solid and has embedded in it two steel rods with hooked ends so that each block can be securely locked or fastened to the adjoining one. Concrete silo block are usually 16 inches long, 8 inches wide and 8 inches high. There are, however, solid block as narrow as 4 inches. In the manufacture of concrete silo block it is



Distance from top of silo	Diameter of silo (inside)					
	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
Feet	1	1	1	1	1	1
	0	0	0	0	0	0
2	1	1	1	1	1	1
	0	0	0	0	0	0
	1	1	1	1	1	1
4	0	0	0	0	0	0
	1	1	1	1	1	1
	0	0	0	0	0	0
6	1	1	1	1	1	1
	0	0	0	0	1	1
	1	1	1	1	1	1
8	0	0	0	1	1	1
	1	1	1	1	1	1
	0	0	1	1	1	1
10	1	1	1	1	1	1
	0	1	1	1	1	1
	1	1	1	1	1	1
12	0	1	1	1	1	1
	1	1	1	1	1	2
	1	1	1	1	2	1
14	1	1	1	1	1	2
	1	1	1	2	2	1
	1	1	1	1	1	2
16	1	1	1	2	2	1
	1	1	2	1	1	2
	1	1	1	2	2	1
18	1	1	2	1	1	2
	1	1	1	2	2	2
	1	1	2	1	1	2
20	1	1	1	2	2	2
	1	2	2	1	2	2
	1	1	1	2	2	2
22	1	2	2	2	2	2
	1	1	1	2	2	2
	1	2	2	2	2	2
24	1	1	1	2	2	2
	1	2	2	2	2	1
	2	1	2	2	2	1
26	1	2	2	2	2	1
	2	1	2	2	1	2
	1	2	2	2	1	1
28	2	1	2	2	1	1
	1	2	2	2	1	2
	2	1	2	2	2	1
30	1	2	2	2	1	1
	2	2	2	1	1	2
	1	2	2	1	2	1
32	2	2	2	1	1	1
	1	2	2	2	1	2
	2	2	2	1	2	1
34	1	2	2	1	1	1
	2	2	1	2	1	2
	1	2	1	1	2	1
36	2	2	1	1	1	2
	2	2	2	2	1	1
	2	2	1	1	2	2
38	2	2	1	1	1	2
	2	2	2	2	2	1
	2	2	1	1	1	2
40	2	2	1	1	2	2

Mortar joints 8 inches apart.

No.3 wires above this line.

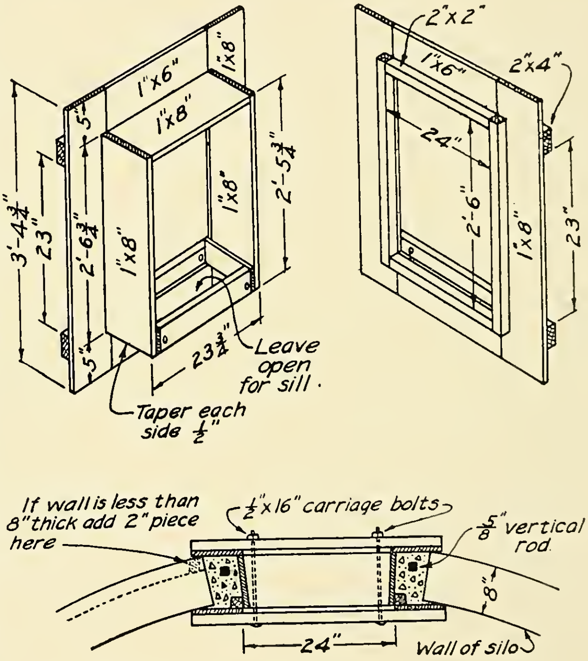
$\frac{3}{8}$ inch round rods below this line.

Chart showing reinforcing required at each joint of concrete block silos.

necessary to use clean, coarse sand. The best mixture for tamped block is 1 part cement to 3 of sand. Block made by the wet process should be made of 1 part cement, 2 parts sand and 3 parts pebbles. All block should be made sufficiently in advance of laying up in the wall to permit them to acquire good strength by hardening for one month. Whether home-made or purchased from a nearby manufacturer, the block should be strong, dense and perfectly shaped.

Laying Up Block Silo Walls

Excavation, floor and footing for block silos are exactly like described for the monolithic silo. After the floor has hardened for a day or two, a circle marking the circumference of the silo can be laid out on the floor by using a sweep. The first course of block is laid to line, bedded on about ½ inch of 1:2 cement mortar. Block in each course are arranged so that an even number of block or half block complete the circle, thereby avoiding the necessity of cutting a block. Care must be taken to insure that the walls are plumb and circular. This is accomplished by constant leveling and plumbing. If a competent mason or bricklayer is employed to lay up the block, a more attractive wall will result and the work will probably be finished sooner, at no greater final cost.



Details of forms for intermittent door in concrete block silo, and cross-section of wall showing form in place.

Reinforcement for Block Silos

Like the monolithic silo, the block silo must be reinforced. A No. 3 (¼-inch) wire is convenient. It is embedded in the horizontal mortar joint. An accompanying table gives the number of strands of wire necessary in each joint. It should be noticed that two strands are not sufficient at the bottom of a large silo, therefore a ⅜-inch round rod or its equivalent is specified for the lower portion. For example, in a 14 by 40-foot silo a ⅜-inch round rod is used in each joint in the lower 6 feet of the silo. From that point up, No. 3 wire is used. As this wire comes in coils, it must be partly straightened before used. This can be done by pulling it over the reel through a piece of ¾-inch gas pipe, 2 feet 6 inches long, curved enough in a direction the reverse of that of the curving of the wire to straighten the wire as required. No. 3 wire is sold by weight; 100 feet weigh about 15½ pounds.

Doors for the Concrete Block Silo

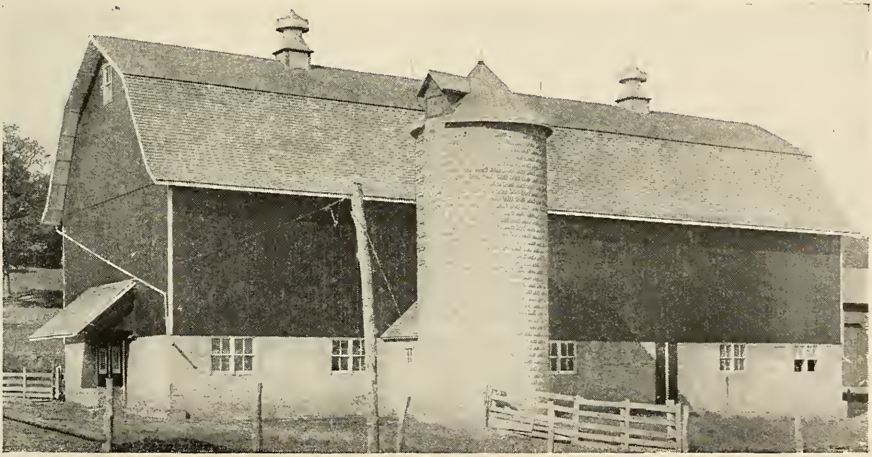
Intermittent doors with concrete door frames are preferable in the block silo. The form shown on page 26 occupies a space in the wall equal to two 16-inch blocks. Wall reinforcing should be securely attached to the vertical rods in the jambs and the vertical rods should be tied together in a manner similar to that illustrated and described for monolithic silos.

A silo wall made of first-class dense block will be smooth and require no finish except a wash of cement water paint. It is usually best, however, to plaster the inside of the silo with cement mortar to secure a smooth surface which will allow the silage to settle and pack evenly. Before applying the plaster coat, the walls should be thoroughly scrubbed down and be wet when the plaster is applied.

Roof and Chute for the Block Silo

The method of building a roof for a concrete block silo is the same as that described for the monolithic silo, except that the eaves are formed by special block which gives the necessary overhang.

Concrete block chutes for block silos may be built up with the wall or after the walls are finished. In either case the chute should be tied to the walls by block, or by metal ties in the mortar joints. To provide a ladder in a concrete block chute, straight rods 2½ feet long are laid across one corner with their ends embedded in the mortar joints.



The ideal location of a silo is that which permits the greatest convenience in feeding the stock.

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Massachusetts Agricultural College
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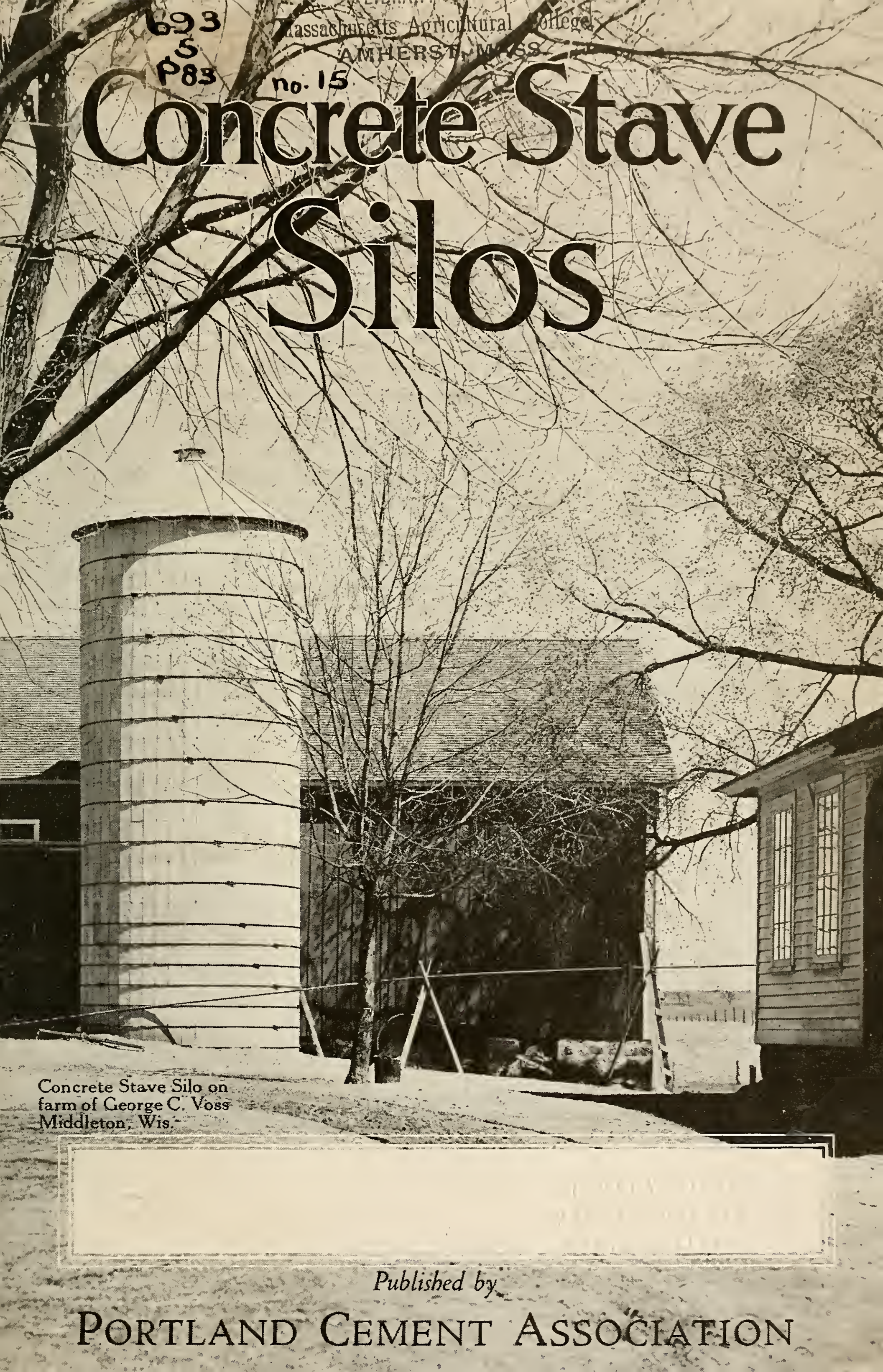
no. 15

Concrete Stave Silos



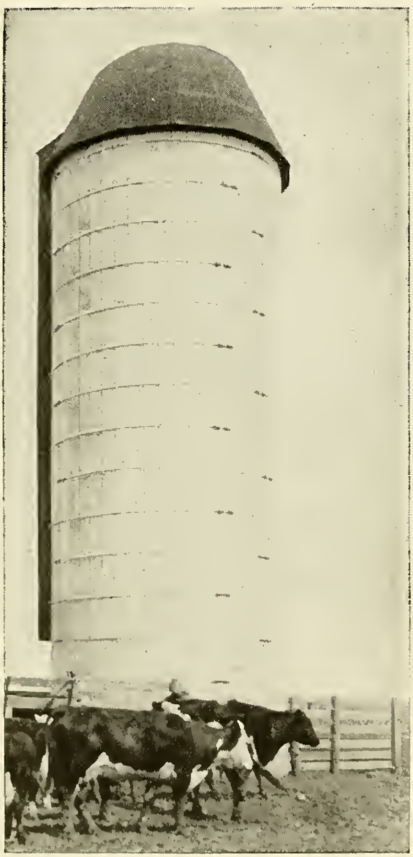
Concrete Stave Silo on
farm of George C. Voss
Middleton, Wis.

Published by
PORTLAND CEMENT ASSOCIATION

Concrete Stave Silos

The Silo from a Business Standpoint

Every live stock farm without a permanent silo has greater need of one today than ever before. Careful management is necessary if the farmer is to make a reasonable profit. Business farmers and experiment stations have found that a silo not only increases farm profits but eliminates many of the uncertainties of live stock raising. A permanent silo protects its owner against loss from fire, storm, drought and crop failure. Many bankers have realized these facts and are urging farmers to build more silos. In many instances, bankers are advancing the money necessary for construction. They know that every silo is adding to its owner's bank account and for this reason they are anxious that every live stock farmer possess at least one silo.



The silo provides economical storage space. Ten tons of silage can be stored in the same space as one ton of hay

SILO INCREASES FARM PROFITS

In a farm management contest conducted in Wisconsin several years ago, records of two years' successful operation were secured from 390 farms which had silos and from 141 farms without them. The farms which had silos showed an average annual net profit of $875 per farm. Those without silos averaged only $535—a difference of $340 in favor of the farm with a silo. These tests were made before the war when prices of farm products were on a low level.

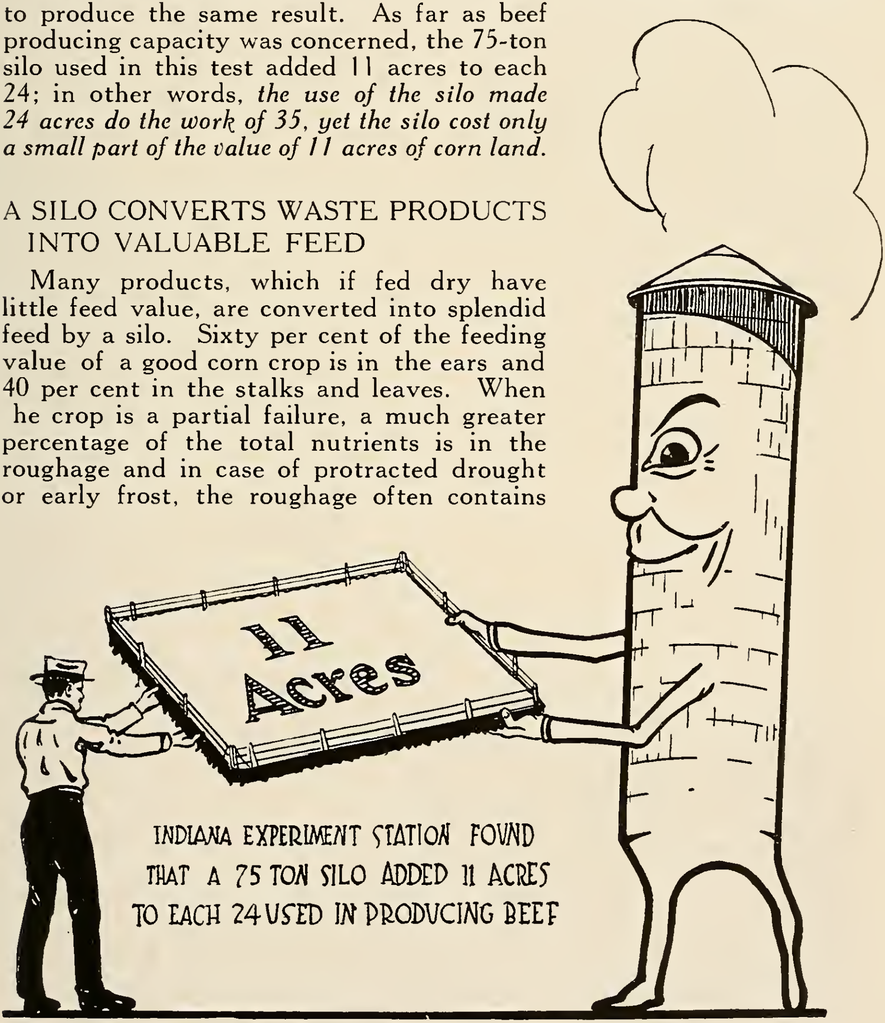
Other investigations similar to this have confirmed the experience of thousands of silo owners, namely, that a silo will usually pay for itself in one year.

WITH A SILO, MORE STOCK MAY BE FED FROM THE SAME ACREAGE

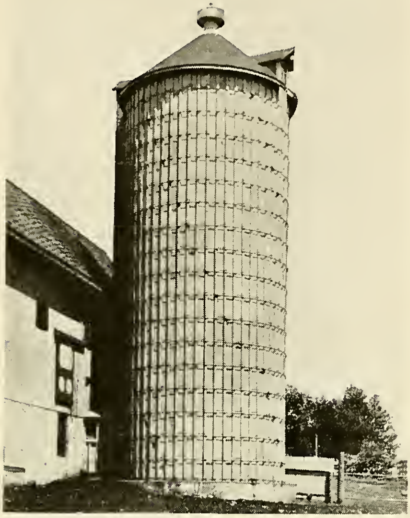
A silo enables a farmer to keep more stock without increasing farm acreage. In tests covering eight years, the Indiana Experiment Station found that an average of 35 acres was required to raise sufficient corn and clover to feed 20 steers for 150 days. When corn silage was used in the ration, supplemented with clover hay, but 24 acres were required to produce the same result. As far as beef producing capacity was concerned, the 75-ton silo used in this test added 11 acres to each 24; in other words, *the use of the silo made 24 acres do the work of 35, yet the silo cost only a small part of the value of 11 acres of corn land.*

A SILO CONVERTS WASTE PRODUCTS INTO VALUABLE FEED

Many products, which if fed dry have little feed value, are converted into splendid feed by a silo. Sixty per cent of the feeding value of a good corn crop is in the ears and 40 per cent in the stalks and leaves. When he crop is a partial failure, a much greater percentage of the total nutrients is in the roughage and in case of protracted drought or early frost, the roughage often contains


11 Acres
INDIANA EXPERIMENT STATION FOUND THAT A 75 TON SILO ADDED 11 ACRES TO EACH 24 USED IN PRODUCING BEEF

24 acres with a silo will produce as much beef as 35 acres without one



A concrete stave silo on a farm is an indication of the good judgment and progressiveness of its owner

practically all the food elements. Putting corn in the crib does not mean that the crop is harvested. It means that *at least 40 per cent is still in the field.* If the 60 per cent put in the crib is worth 50 cents a bushel, it means that for each bushel of corn harvested there is 33 cents of value left in the field. No farmer can afford to waste 40 cents out of every dollar, when by putting his corn crop in a silo he can get its full value.

SILO PRODUCES FEED ECONOMICALLY FOR DAIRY CATTLE

As a succulent, economical feed for dairy cattle, silage has no equal. It is a money-maker because it produces results in the milk pail. It keeps up the flow of milk when pastures get short and keeps this flow continuing during the winter months at much less expense than dry forage. In fact, dairying can hardly be made a profitable enterprise in most localities without a cheap feed, which the silo makes available.

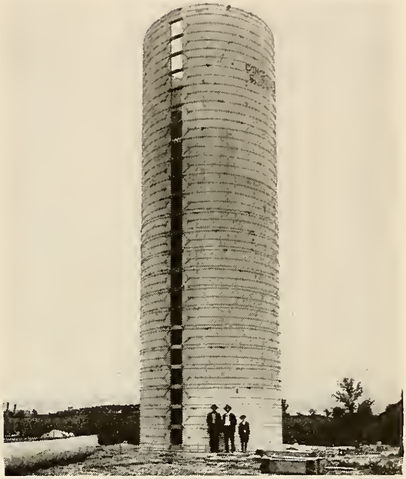
The Ohio Experiment Station in its Bulletin 155 shows that a silage ration produces butter fat for 41 per cent less cost than a grain ration. In the Upper Iowa No. 2 Cow Testing Association, a herd of 16 cows

The first cost of a concrete stave silo is the only cost. Its permanent construction does away with costly maintenance expenses fed on a ration including silage made twice as much profit per cow as a similar herd without silage. Successful dairymen everywhere recognize the silo as their best aid, and are building summer silos to use when pastures fail.

SILO PRODUCES BEEF AT LOWER COST

In recent years the silo has become as essential to the cattle feeder as to the dairyman. E. W. Houx, President of the Kansas City Live Stock Exchange, also a farmer and cattle feeder, sums up the situation as follows:

> "Every up-to-date farmer will concede that for winter feeding of cattle he must have silage, and I believe I can assert that the time has come when beef cannot be produced in the winter without this succulent feed."



This 20 by 65-foot concrete stave silo holds over 500 tons of succulent feed

40 per cent of your year's work is lost when the corn stalks are left in the field. A silo makes your labor 100 per cent productive

Farthest silo was built in 1915 and went through a severe fire which destroyed the old barn

The value of silage to the beef feeder was demonstrated by experiments completed in 1918 at the Iowa Experiment Station. In these tests, *232 more pounds of beef were produced from feed grown on one acre when silage was included in the steer's ration than when alfalfa was fed.*

The table below indicates the amounts and kinds of feed required to produce 100 pounds of beef with each ration.

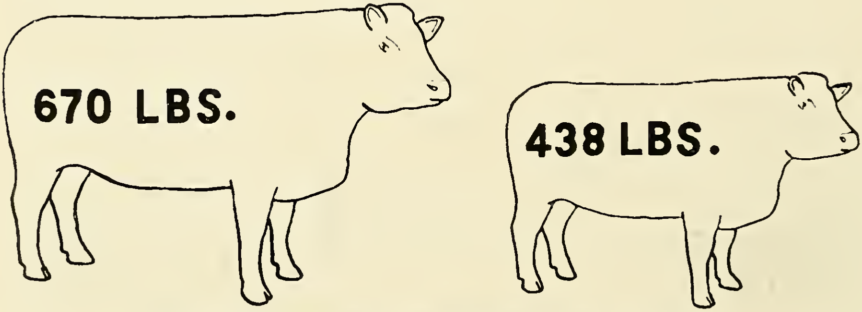
SILAGE RATION

Kind of Feed	Pounds	Acres to Produce
Shelled corn	119	.0425
Corn silage	1806	.100
Alfalfa	46	.0065
Oil meal	89	
		.149

ALFALFA RATION

Kind of Feed	Pounds	Acres to Produce
Shelled corn	519	.185
Alfalfa	301	.043
Oil meal	72	
		.228

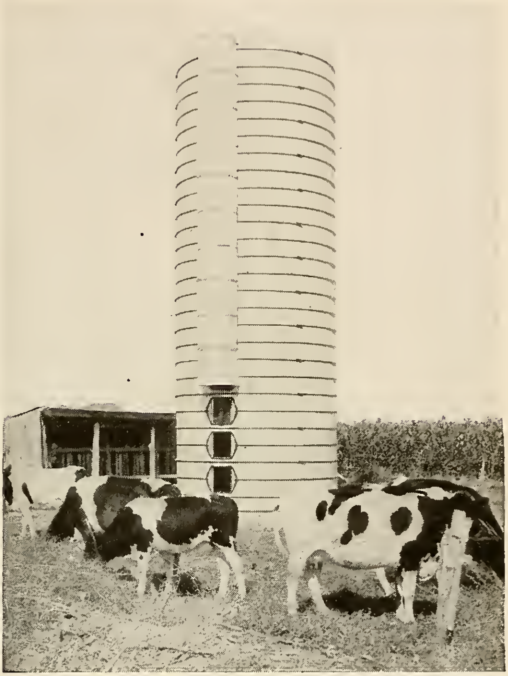
In other words these results on the basis of one acre mean that 670 lbs. of beef will be produced with the silage ration, against 438 lbs. for the alfalfa ration.


670 LBS.
438 LBS.

Beef produced on one acre—at left with silage, at right with alfalfa

Evidence proving the economy of silage is so conclusive that many cattle feeders are replacing practically all the grain with silage. In this connection the Missouri Experiment Station says:

> "It is evident that a good grade of beef may be produced by this method of feeding, and results at this Station have shown the greatest profits from rations in which silage and nitrogenous concentrate (oil meal, cottonseed meal, etc.) have been fed without the addition of corn. Its extensive adoption by feeders will make possible an economy in the production of beef which is of national importance."



A silo enables a farmer to keep more stock without increasing his acreage

Four state experiment stations conducted tests during the winter of 1918-19, to determine the amount of silage to be fed for the most profitable beef production. At each station one lot of steers was given 25 pounds of silage, 15 pounds of grain, together with hay and some concentrated feed, while another lot was fed from 40 to 60 pounds of silage with no grain. In every case the most economical gains and the largest margin of profit were made by the steers getting the heavy silage ration.

Prosperity attends the use of a concrete stave silo. It gives a more business-like appearance to the farmstead

Concrete stave silos insure the ranch owner against lack of feed during dry spells

Below are given the results of the tests, based on 1918 and 1919 prices:

	Cost of 100 lb. Gain		
Experiment Station	Medium Amount of Silage with Grain	Heavy Silage Ration—No Grain	Saving Due to Silage Ration
Iowa (crediting hog gains at $20)	$19.79	$14.80	$4.99
Kansas	21.34	12.07	9.27
Missouri (crediting hog gains at $17.50)	15.58	11.68	3.90
Wisconsin	23.23	15.88	7.35

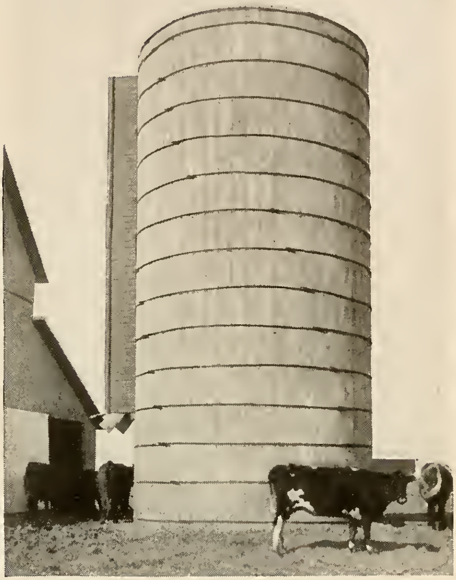
Seven years of investigation at the Iowa Experiment Station proved that silage-fed lambs cost least to produce

SILAGE KEEPS HORSES IN CONDITION

Silage may be successfully fed to horses. Tests made by the Pennsylvania Experiment Station showed that silage combined with other feeds can be given to horses with excellent results. Horses which were fed a small amount of grain combined with silage were in much better condition at the end of the experiment than those receiving no silage.

SILAGE GOOD FOR FEEDING LAMBS

Seven years of investigation at the Iowa Experiment Station shows that silage-fed lambs make satisfactory gains and cost 13 per cent less to produce than those receiving a ration without silage.



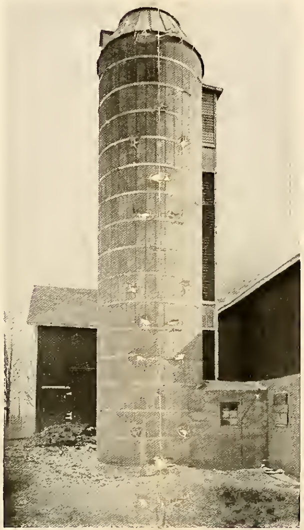
During summer droughts a full silo makes it possible to carry stock over to fall pasture

This pair of concrete stave silos is helping a Colorado cattle feeder produce beef at a profit

Silage may also be fed to breeding ewes, at the rate of two pounds of silage to each pound of clover or alfalfa hay. Fed after the lambs are dropped, silage aids in producing milk and promotes rapid growth of the lambs. Silage-fed ewes also experience no digestive disturbances when first turned out into spring pasture.

A Few of the Many Concrete Stave Silos That Are Making Money for Their Owners

A concrete stave silo on your farm will put money in *your* pocket also.



SILO SAVES MONEY DURING A DRY SEASON

A silo is a money-saver during a drought. E. A. Trowbridge, head of the Department of Animal Husbandry, University of Missouri, says:

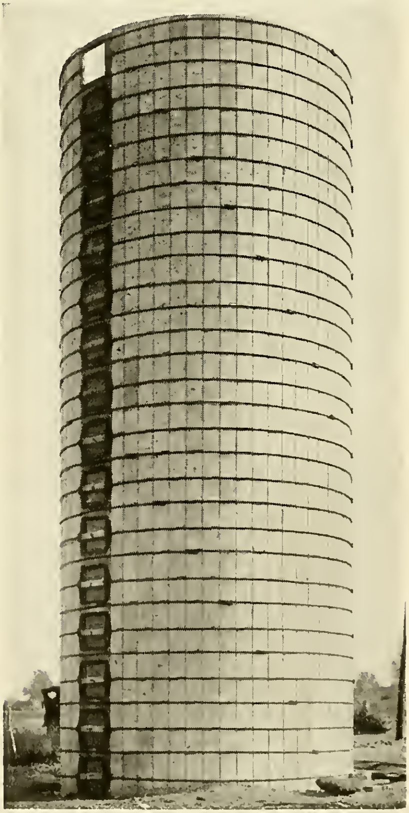
"During the summer droughts and bare pastures a full silo makes it possible to carry stock over to fall pasture. The man who is forced to sell during one of the drought periods has to sell on an over-run market and consequently does so at a sacrifice. The same stock held until November frequently nets a good profit, where a forced sale during the drought would show a decided loss. A supply of silage also makes it possible for the man with a silo to buy stock at a relatively low price during times of scarce feed.

"In short, a reserve supply of feed in a silo keeps a man from being at the mercy of the open market, glutted by shipments from thousands of farms where feed is not available."

SILO MAKES GOOD FEED FROM FROSTED CORN

A corn crop caught by an early frost can easily be saved in a silo. C. F. Collins, of Danville, Ill., who has had experience along these lines, voices the opinion of hundreds of farmers in saying:

"I filled my silo late last fall with frostbitten corn. The corn was so soft that it would have been a clear loss to me if I had been without a silo. I believe the silo one of the best investments I have ever made."



A corn crop caught by an early frost can be converted into valuable feed by the use of a silo like this one

E. E. Hart, a large feeder at Monrovia, Ind., hits the nail on the head when he says:

"When frost gets corn it is possible to save hundreds of dollars' worth of good feed with a silo."

SILO HANDY FOR WINTER FEEDING

The farmer who has had the experience of digging and chopping a load of fodder out of snow and ice when the temperature is around zero, knows how to appreciate a silo with its supply of easily accessible feed for the stock.

SOME OTHER REASONS WHY THE SILO PAYS

A silo can be filled in wet as well as in dry weather. Once the crop has reached the right stage of maturity, there need be no delay in putting it into the silo.

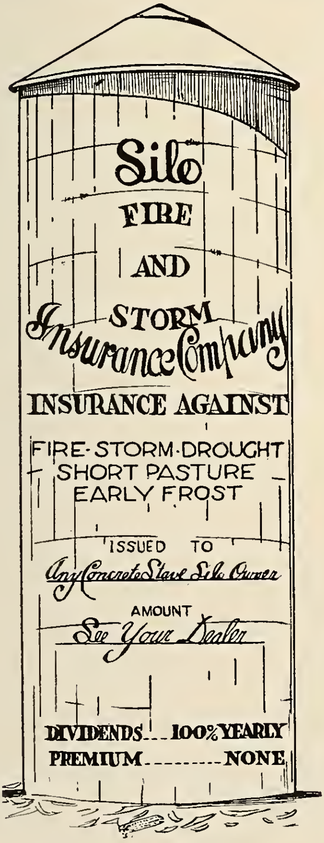
A silo enables the farmer to clear his land to prepare it earlier for fall seeding of rye or wheat.

A silo is an economical storage place. Ten tons of silage can be stored in the same space as one ton of hay.

The Concrete Stave Silo

The concrete stave silo is built of concrete staves, held in place by wrought iron or steel hoops. The stave is a slab of concrete, usually about 30 inches long, 10 inches wide and 2½ inches thick. Some types of concrete staves vary slightly from these dimensions. The method by which the staves are joined also differs somewhat, according to type. Some have tongued and grooved edges, while others have concave and convex edges, or some other form of interlocking edge so designated that the staves will fit together snugly and make an air and water-tight silo. As a further safeguard against possible leakage at the joints, the interior of a concrete stave silo is given a wash of cement and water mixed to the consistency of thick cream.

A fire destroyed this barn but left the concrete stave silos intact with their contents unharmed. The owner's live stock was carried comfortably through the winter on the silage



A concrete stave silo is the safest and most economical kind of crop insurance

The concrete door frames and staves are made in a factory by skilled workmen. Their work is under constant supervision so a high class product results. The erection of the silo is handled by the manufacturer, thus enabling the farmer to buy a complete silo erected on his farm and ready to be filled.

Since 1905, when the first concrete stave silo was built, this type has become so popular that in practically every state where live stock is raised, there are contractors engaged in the concrete stave silo business. Thousands of these crop-saving structures are built every year. The rapid increase in popularity of the concrete stave silo may be attributed to the fact that it fulfills all essentials of a good silo at a reasonable cost.

Why to Buy a Concrete Stave Silo

SILO MUST BE AIR AND WATERTIGHT

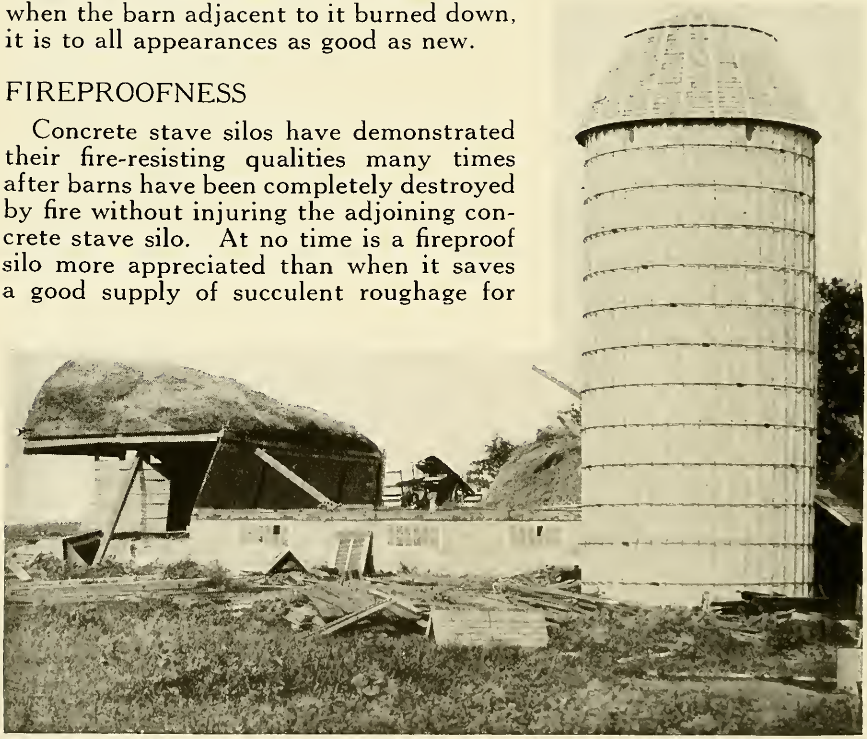
To keep silage, the juices must be prevented from leaking and the air kept out of the silo. A concrete stave silo keeps silage perfectly because it is air and watertight. Proof that concrete staves are watertight is furnished by the fact that they are used quite extensively to build water tanks. In the process of manufacture, each stave is accurately moulded so all fit together closely. Air and watertightness are made doubly sure by painting the inside of the silo with a cement-water wash like that described on the preceding page, which also seals the joints and produces a smooth wall. This makes it easy for the silage to settle.

DURABILITY

The careful buyer chooses the permanent silo, thus insuring continuous and satisfactory service for a lifetime or longer. The staves of such a silo will grow stronger as the years go by. The first concrete stave silo, built in 1905 on the farm of Mr. Kimmerli, Cassopolis, Mich., is still rendering satisfactory service and in spite of having passed through a severe fire several years ago, when the barn adjacent to it burned down, it is to all appearances as good as new.

FIREPROOFNESS

Concrete stave silos have demonstrated their fire-resisting qualities many times after barns have been completely destroyed by fire without injuring the adjoining concrete stave silo. At no time is a fireproof silo more appreciated than when it saves a good supply of succulent roughage for

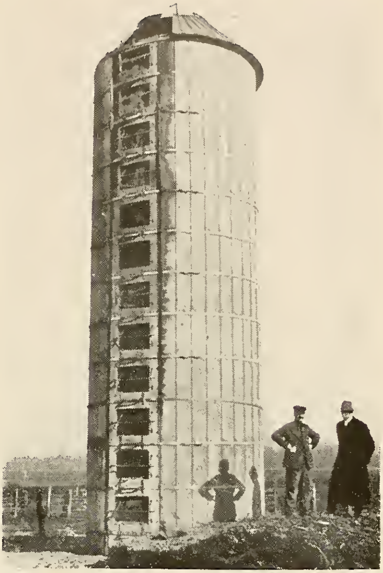


This concrete stave silo is one of a number of this type which successfully withstood a terrific tornado at Fergus Falls, Minn.

the farmer whose barn filled with hay and other feed has been burned.

STORMPROOF

Concrete stave silos that successfully withstood the tornadoes at Fergus Falls, Minn., and Newcastle, Ind., and the Gulf Coast storms in Texas, furnish abundant proof of the great strength of the concrete stave silo. The heaviest windstorms usually occur during the summer months when a silo is often empty. The owner of a concrete stave silo runs no risk of having his silo damaged by storms.



The silage in this silo was the only feed that Joseph Able of Walkerton, Ind., had left after his adjoining barn burned down. Not a stave was cracked

EASILY AND QUICKLY ERECTED

Ease and speed of construction are two important features in favor of the concrete stave silo. Boarding and lodging a large silo-building crew does not appeal to the farmer's wife. She will be pleased by the announcement that a concrete stave silo is to be built. Instead of the work of providing meals for a large crew for a week or ten days, it means the keeping of only three or four men at most, for not longer than two or three days.

A concrete stave silo can be quickly erected by a small crew

DEPENDABLE WORKMANSHIP

Proper construction is practically assured in a concrete stave silo. The purchaser can inspect every stave before it goes into the silo. Erection is done under the personal supervision of a factory man, who stays on the job until it is completed. The contractor assumes all of the responsibility of correct erection and backs his silo with a guarantee covering workmanship as well as materials. The lasting success of the concrete stave silo builder's business depends largely upon his furnishing a first class silo. He cannot afford to slight the job.

ECONOMICAL

The enduring and lasting construction of a concrete stave silo makes the first cost the only cost. There will be no replacement of staves, no painting or other costly maintenance expenses.

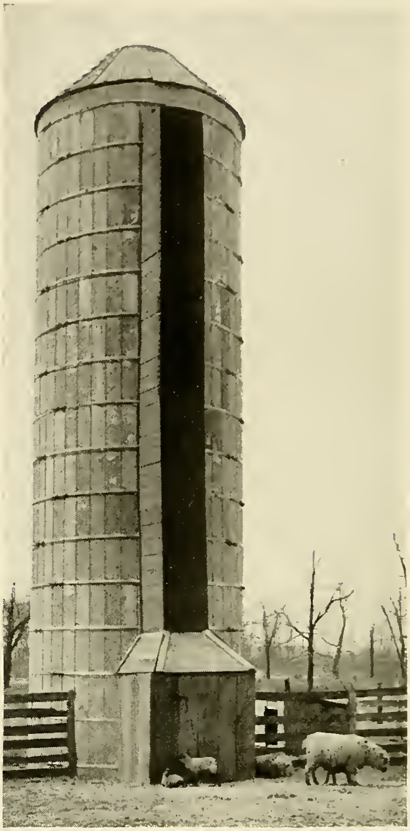
FROSTPROOF

Testimonials from many practical farmers having concrete stave silos furnish ample proof that silage does not freeze excessively in silos of this type. Mark O. Smith, a prominent feeder of Attica, Ind., makes a statement with regard to concrete stave silos, which is representative of the many satisfied users:

> "I find that when taking out silage there is less freezing to the walls than in other silos and with a little bit of sunshine it will loosen and fall from the walls."

A GOOD INVESTMENT

Bankers are urging farmers to build concrete stave silos. The farmer with a silo of this type is a good financial risk. He has demonstrated his foresight and sound business judgment by protecting himself against loss by fire, drought and early frosts. Likewise a concrete stave silo is the safest farm improvement on which to borrow money. Because of the great saving of feed and the increased profits effected by its use, many silo owners testify that their silos returned their full cost the first year.


The sure way to increase farm profits is to build and use a concrete stave silo

Experiments have clearly shown that for the economic production of milk, beef and mutton, the silo can be used to great advantage and in a majority of cases is a necessity. In establishing herds of cattle on two farms in southern Indiana this season, Purdue University has erected two concrete stave silos. It is our belief that the silo is as necessary as is the barn in which these cattle are kept. The farmer who undertakes the operation of a farm requires equipment and implements. Where livestock is to be kept the silo should be recognized as a necessary part of the farm equipment.

G. I Christie,
Director, Purdue University
Agricultural Experiment Station.

How to Determine the Size of Silo to Buy

What size of silo to build depends upon the number of animals to be fed and the length of the feeding period. The diameter decided upon should be based on the removal of at least 2 inches of silage each day.

Tables I and II will help the buyer to determine the size of silo to build. For example, let it be supposed that a farmer wants to know the proper size silo to build for his herd of 15 dairy cows, 10 steers, 7 horses and 20 head of young stock. Length of the feeding period is 180 days. He could proceed as follows:

Silage for 15 dairy cows at the rate of 40 lb. each daily	600 lb.
Silage for 10 steers at the rate of 30 lb. each daily	300 lb
Silage for 7 horses at the rate of 20 lb. each daily	140 lb.
Silage for 20 head young stock at the rate of 15 lb. each daily	300 lb.
Total amount of silage required daily	1340 lb.
Total required for 180 days	121 tons

TABLE I. RELATION OF SIZE OF HERD TO DIAMETER OF SILO

Inside Diameter of Silo in Feet	Pounds of Silage in Depth of 2 Inches	Number of animals that may be fed, allowing			
		40 pounds per head daily	30 pounds per head daily	20 pounds per head daily	15 pounds per head daily
10	525	13	17	26	35
12	755	19	25	37	50
14	1030	25	34	51	68
16	1340	33	44	67	89
18	1700	42	56	85	113
20	2100	52	70	105	140

TABLE II. CAPACITY OF ROUND SILOS IN TONS

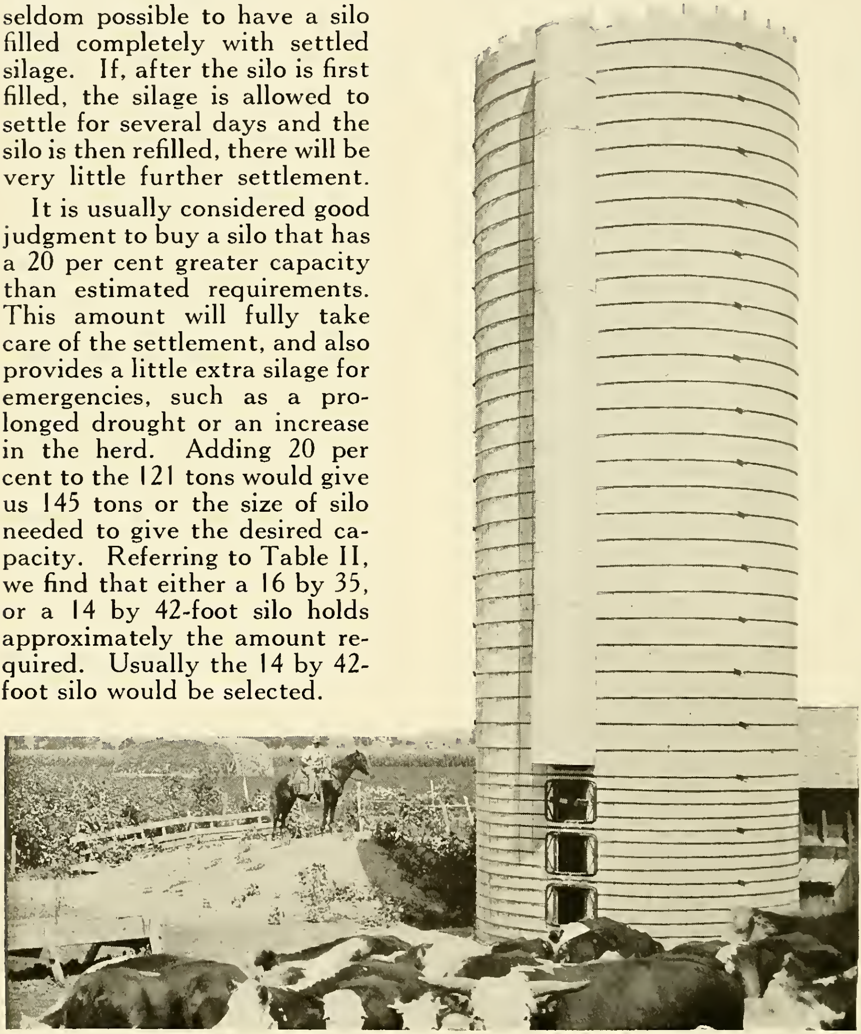
	Diameters					
Height*	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
27½	41 tons	58 tons	81 tons	. . . tons	. . . tons	. . . tons
30	46 "	67 "	91 "	119 "	. . . "	. . . "
32½	52 "	75 "	102 "	134 "	. . . "	. . . "
35	58 "	83 "	114 "	149 "	188 "	. . . "
37½	64 "	92 "	126 "	163 "	208 "	. . . "
40	70 "	101 "	138 "	180 "	229 "	280 "
42½	. . "	111 "	151 "	196 "	249 "	304 "
45	. . "	121 "	165 "	215 "	269 "	330 "
47½	. . "	. . . "	. . . "	232 "	289 "	356 "
50	"	. . . "	. . . "	250 "	310 "	382 "

*Heights are given in intervals of 2½ feet, the common length of concrete staves.

Referring to Table I, we find that 2 inches of silage in a silo 16 feet in diameter weighs 1,340 pounds, or precisely the daily requirements of the above herd. Therefore the silo selected should not exceed 16 feet inside diameter. It is common practice for farmers to order a silo of such diameter that more than 2 inches will be fed daily. Often it is more convenient to erect two small rather than one large silo. The combined contents of a 10-foot silo and a 12-foot silo have practically the same weight per foot of depth as the contents of one 16-foot silo. The advantage in having two silos lies in the fact that one may be used for winter feeding and the other for summer.

Now let us determine the size of silo required to furnish feed for 180 days. We have already found that we must have capacity for 121 tons of silage. Silo capacity tables are usually based on the weight of packed silage and do not make allowance for settlement. It is seldom possible to have a silo filled completely with settled silage. If, after the silo is first filled, the silage is allowed to settle for several days and the silo is then refilled, there will be very little further settlement.

It is usually considered good judgment to buy a silo that has a 20 per cent greater capacity than estimated requirements. This amount will fully take care of the settlement, and also provides a little extra silage for emergencies, such as a prolonged drought or an increase in the herd. Adding 20 per cent to the 121 tons would give us 145 tons or the size of silo needed to give the desired capacity. Referring to Table II, we find that either a 16 by 35, or a 14 by 42-foot silo holds approximately the amount required. Usually the 14 by 42-foot silo would be selected.



The concrete stave silo is a profitable partner in the live stock business because steers make rapid and substantial gains when they receive a heavy silage ration

Farmer Putman on Silos

A SILO is a hole, entirely surrounded by a wall, fur storin' cow feed. Sometimes the hole is in the ground; sometimes it is up in the air. To build a silo, first select a nice spot fur the hole, then build a wall outside of the hole, if you want to build up, or inside of the hole if you want a pit silo. Either kind is good, but you got to go about it different. If you can't put up a silo, put one down, but don't put it off.

All kinds of material is good for silo buildin' exceptin' hot air. Good ones is made outen cement, concrete, cement staves, or slabs, holler tile, brick, stone, wooden staves, steel, or two-by-fours. We has 2,000 silos in Colorado made of them above materials and about 20,000 outen hot air. Most of the farmers has got the spot fur the hole picked out, but they hain't never begun to commence to build yet, fur some reasons or others. Some hain't got the money, some cain't decide on the kind of silo, some sez it's too much work to haul the crop in and cut it up, some sez it makes the cows' teeth fall out, some sez it gives 'em holler horn and holler tail, some sez it makes the milk turn green, some sez the butter from the silage milk won't churn, some sez it makes steers scour, hawgs howl, and lambs limp. Anything to put off silo buildin'. I'm a tellin' you folks better get busy and look into this silo business; it'll mean money fur farmers that wants to make beef, mutton, or milk, and I know of some that feeds it to hawgs and lots of it is fed to hosses and mules. I wouldn't starve on it myself if I had to eat some good corn silage.

—THOMAS JEFFERSON PUTMAN.

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CONCRETE SURFACE FINISH

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LAND TITLE BUILDING, PHILADELPHIA

CONCRETE SURFACE FINISH.

The Artistic Architectural Possibilities of Concrete.*

The principle of reinforcement by means of steel rods, wire mesh, or light bars in truss form has given to concrete a leading place among structural materials. It marks a departure in many essentials from traditional construction, and therefore must exert a like influence upon design. For this reason it has become a subject of absorbing interest in the architectural world, as it presents new problems not only of structure, but also of ornamental and, possibly, even of stylistic expression. The many practical advantages of concrete and the increasing scarcity of lumber assure it a prominent place in the architecture of the future.

Quite a little work which has already been produced is suggestive of appropriate treatment of form and surface. Still, the bulk of concrete building so far has been on purely commercial or engineering lines. We are as yet feeling our way on the outskirts of a new field of design.

Concrete furnishes opportunities of surface treatment, as the incrustation of tile, contrast of plain surface with color ornament and wrought metal motives of delightful promise, in which some successful work has already been accomplished.

Concrete is by no means a new building material, but not until recently did it occupy any but a secondary position. The Romans were the most notable users of this material, though entirely as a useful substitute for more costly masonry or as a material for rough walls which would be faced with stone or brick. The articulations natural to the latter materials would therefore be expressed; the concrete was merely a backing. (See Fig. 1.)

Stucco was sometimes used as a finish for walls. This had been quite a frequent method in still earlier times, and was again later, in the Italian Renaissance, when architectural masonry detail was much imitated in this medium. The same thing is done very frequently to-day.

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* Extracts of a paper published in "The Architectural Record," by A. D. F. Hamlin.

The stucco building, when it breaks away from being a replica of stonework executed in a cheaper material, tends to develop a plasticity of treatment, a monolithic breadth and surface texture of its own. There is little distinction, as a matter of design, between plastering mortar on walls of brick, clay blocks, or concrete, if the latter is not

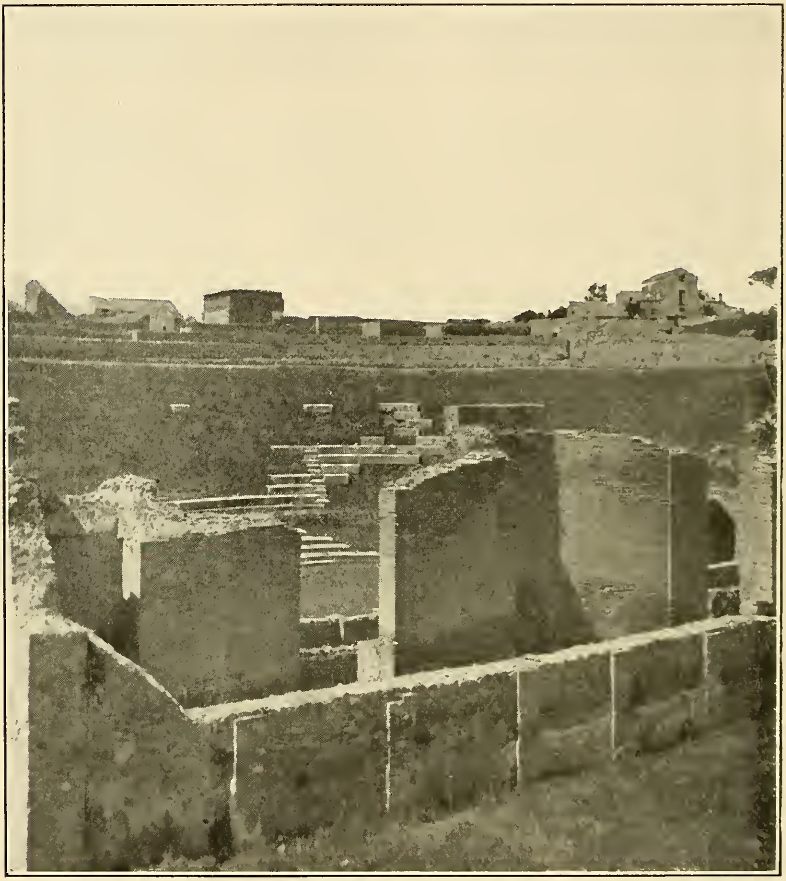

Fig. 1.—Ruins of Comic Theatre in Pompeii, walls of which were made of concrete, covered with marble slabs, some of which still remain.

part of a reinforced monolith. A solid concrete wall is scarcely more than a form of rubble masonry, but one which the fineness of the aggregate makes it easier to render with a presentable surface. But the development of concrete construction has advanced considerably beyond this.

Several methods are now in vogue in which concrete is used, with greater or less completeness, as the structural material. First, there is the above-described stucco on brick or on metal lath over frame. This cannot be classed as concrete architecture, except in so far as it implies some of the same motives to a limited degree, having superficially the plasticity of cement. It is often attractive, but is contradictory, and therefore must borrow and imitate whenever the simple value of surface seems insufficient and form is indulged in.

Then we have concrete block construction, but this method possesses even less of the real characteristics of concrete. It is, in fact, purely a work in artificial stone. Very few attempts have been made to treat concrete blocks with any artistic sense; when it has been done, however, using large blocks finished to reproduce stone and designing all features just as for stone, it has been shown to be not without scope. (See Fig. 2.) However, it is unproductive of new thought in design, beyond the matter of finish to reproduce something else.

The first of the characteristics of concrete as an architectural material is its *plasticity*. Technical language adopts the term "pouring into the forms," which concisely implies the impressionable nature of the medium, while it describes the actual method of emplacement. Such material calls naturally for molded, flowing forms growing out of the body material, in contrast to the principle of detachment of forms and the putting together of them in small units, which ideas govern architectural construction and ornament in stone. (See Fig. 3.)

Concrete structure is not merely plastic but lends itself to treatment in large masses; it is *monolithic*. This is the second characteristic of general import, carrying with it the distinction we have just noted. The indication of joints is of course illogical, because such would be merely a pretense of what does not actually exist.

It will be seen from these tendencies that logical form, as it may be expressed architecturally in concrete, makes for severity and simplicity. In all former styles the emphasis of joint lines has been a favorite mode of expression. In this new material plain surface must be mostly depended upon. Conventional form, as it has been handed down to us, is permeated with the feeling of the cutter's

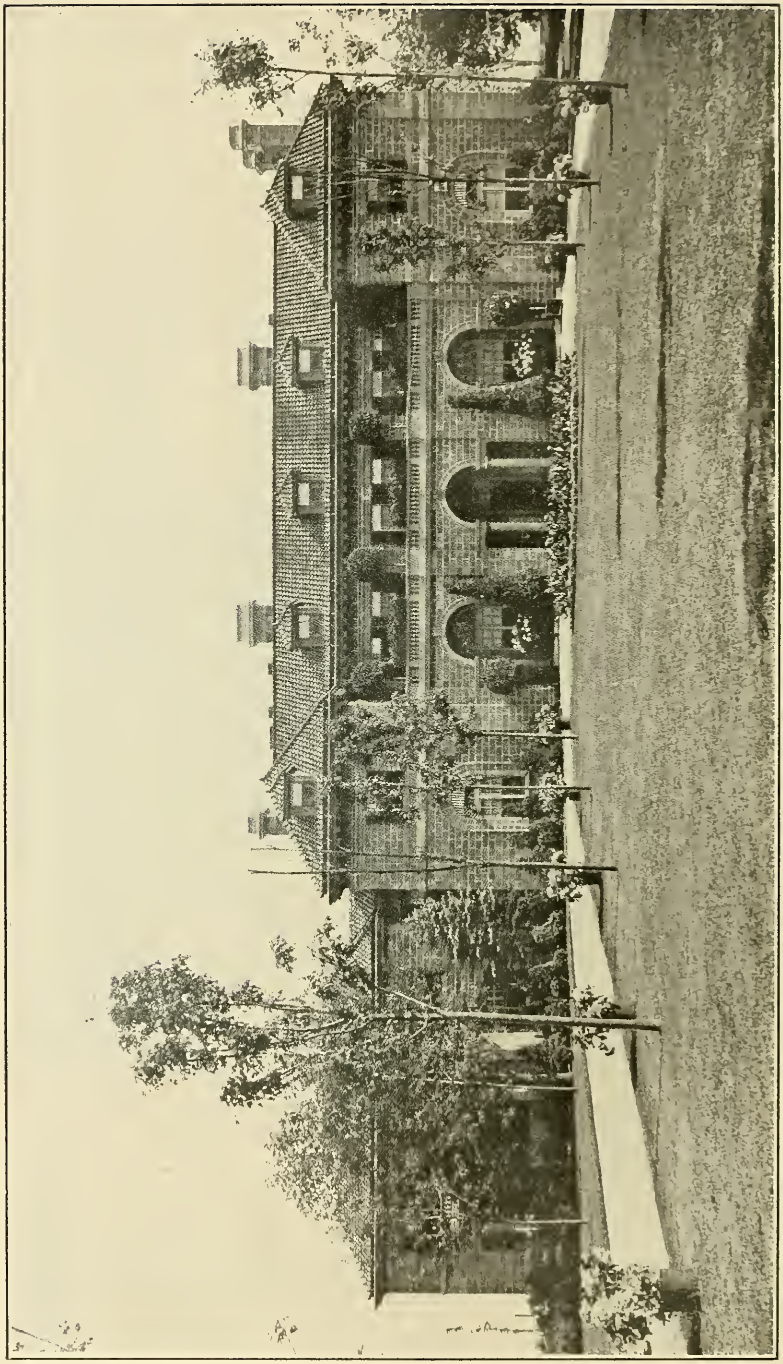

FIG. 2.—A pleasing example of large concrete block construction.

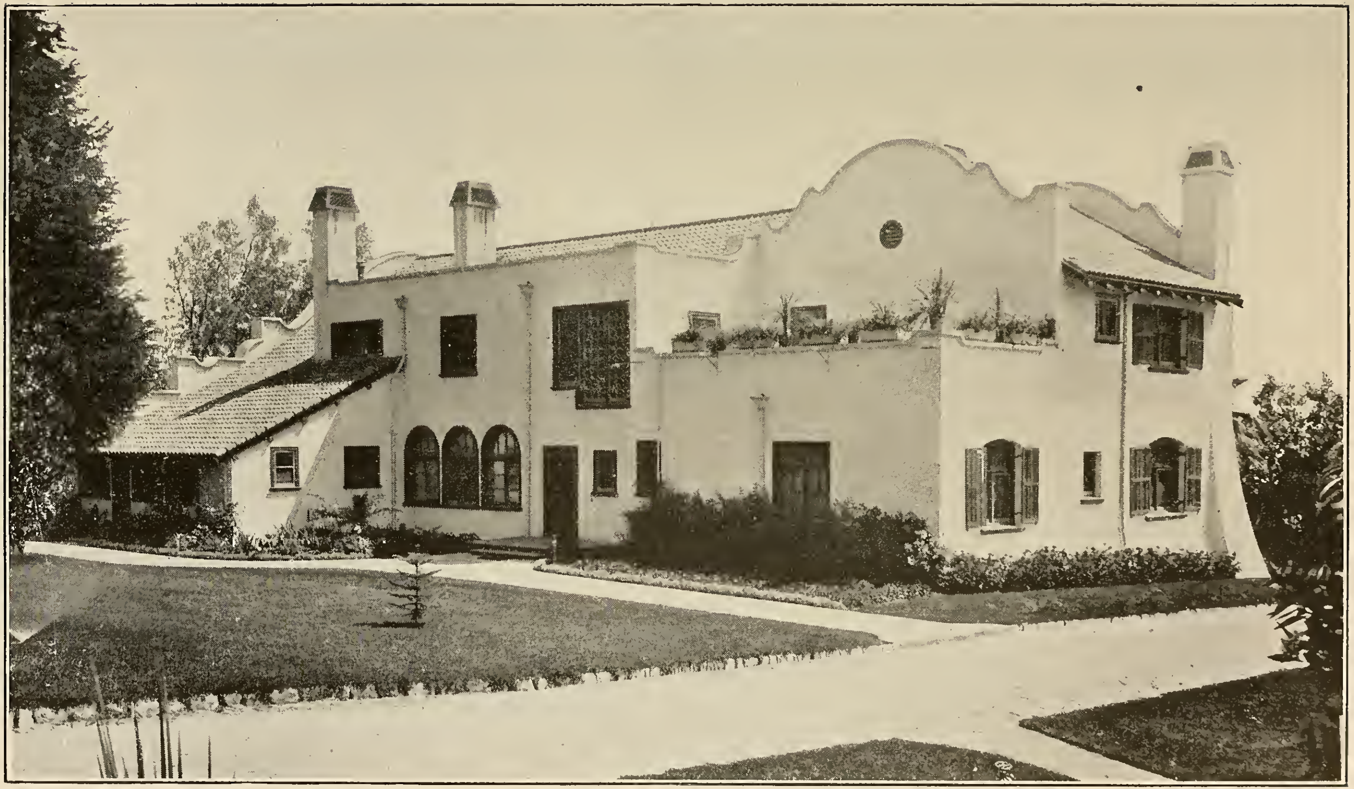

FIG. 3.—Showing a house of ideal concrete design, where every line suggests a poured building material.

tools. One sees this in the straight lines and sharpness of moldings and in clear-cut carving. Concrete ornament should show evidence of molding rather than sculpturesque quality. Line has diminished in importance, surface and color have gained. Mechanically, as well as esthetically, the elaborate forms of stone architecture, heavily projected and accurately finished, are contrary to the nature of concrete and the methods used in its erection.

Since so much that has seemed positively essential to design, at least for all large problems where formal elaboration is called for, is denied the concrete designer, he must evidently either veneer the structure with other materials in the same unrelated manner as is done with a steel frame, or must seek other sources of inspiration. A motive prolific in opportunities is offered in the use of faience and tile. Pattern is the natural form of enrichment for flat surface, and nothing is more consistently in harmony with the unmechanic and plastic, though durable, surface of concrete than ceramic tile and faience. The tile may be modeled in low relief, or, again, may be mosaic inlays of colored marbles or terra-cottas in geometric patterns. The quality of the concrete surface permits an expression of the hand-made rather than of the mechanically finished. (See Fig. 4.)

Color, of course, may be indulged in without stint. To be sure, it is rather fearful to think what may be in store for us in the way of chromatic outbursts should the speculative suburban builder turn his attention to this subject. In any event, polychromy and incrustation or veneering with thin slabs or tiles in appropriate motives are destined to be leading characteristics of concrete design. Recognized laws of ornament and style will determine the relative value of location and distribution or concentration; capitals, pilaster panels, spandrels, tympana of arches, are natural points for accent. As a general rule, such enrichment is more effective when highly concentrated upon certain central motives of a design and allowed to contrast with expanses of plain surface. One of the limitations of decoration of this type is that it inclines to smallness of scale; thus suggesting its better adaptability to the refinements of a small edifice than to the monumental proportions of a building in the grand manner of the Italian or French tradition. In other words, it is more properly decoration than architecture in a monumental sense.

Fenestration assumes an important place in concrete design. In many compositions there will be an obvious opportunity to strike a contrasting note to plain wall surface by the introduction of richly ornamental metal frames and mullions or sinuous tracery, if the latter

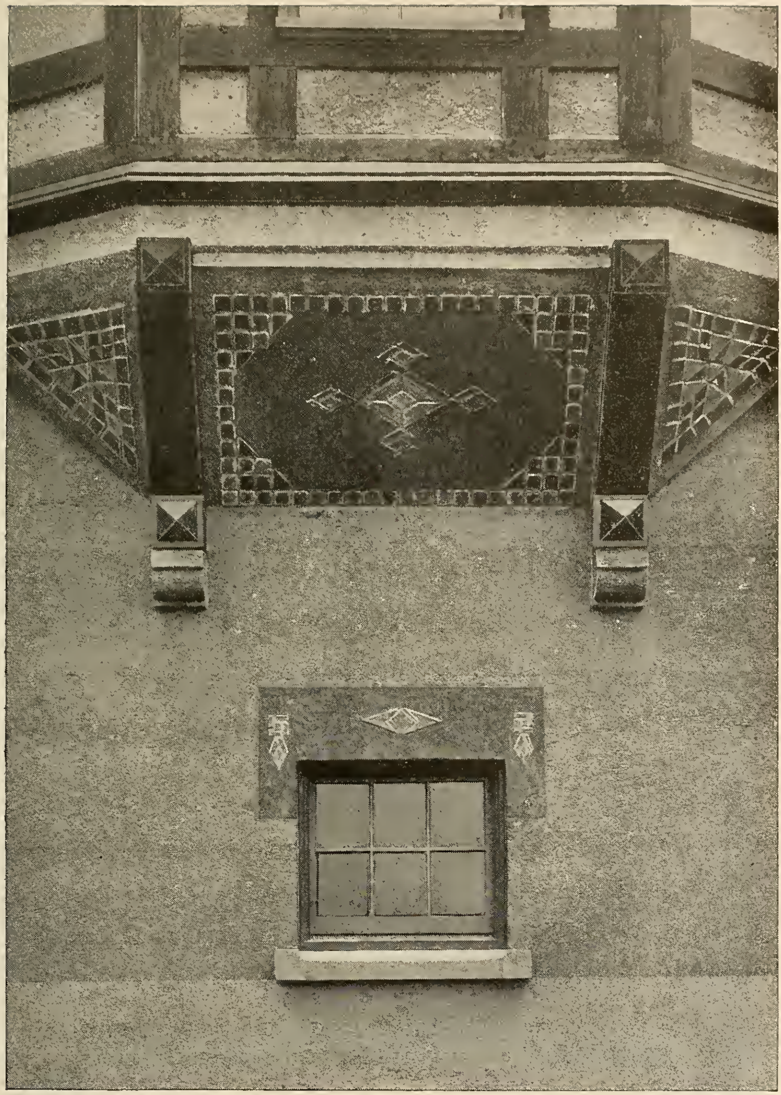

Fig. 4.—The concrete relieved by panels of burnt clay and tile. These tiles were cast in a slab in a factory and placed in the walls as panels.

would be in harmony with other motives or style used. Wrought-iron balconies, gateways, and lanterns will be valuable accessories. (See Fig. 5.) We believe, too, that hammered copper for certain purposes, such as copings and cornices, may be used not irrationally and certainly with beauty of effect. Of course, where metal is so applied it should be acknowledged and its characteristics emphasized, not disguised.

The finish and texture and tone of concrete surfaces may be varied according to what seems best to harmonize with the character of particular buildings and designs, as will be referred to more at length presently.

Such are some of the motives, full of imaginative promise, that are open to concrete and that should prove, in the problem of the small building, at any rate, an adequate compensation for the forced abstinence from the architectural formalities we have become accustomed to, but which are phrased so entirely in the language of stone.

The treatment of surface is one of the most important matters concerned with the architectural possibilities of concrete. As laid up with care, but purely for utility—a rather wet mixture, well tamped in forms of average regularity, being used—a fairly smooth but regular surface results, a film of mortar settling against the sides of the mold. However, every irregularity and almost every joint of the boarding leaves an imprint. Patches of exposed aggregates show here and there and variations in color occur in streaks and layers. In short, such a surface is not merely dull and uninteresting; its inconsequent irregularities are objectionable. Several methods are in vogue aiming at the production of an even texture and one agreeable to the eye. Two quite opposite effects may be had: one consists in brushing and washing away the cement skin, thus exposing particles of aggregate; in the other method a surface mixture of selected material is applied to the surface of the molds, just ahead of the pouring of the concrete, and, on removal of the forms, the surface may be further finished by washing or tooling. (See Fig. 6.)

The first of these methods frankly admits and displays the material as concrete. Some very delightful and varied effects may be obtained by using aggregate of graded sizes and mixing in a certain proportion of pebbles, marble screenings, burnt clay, or broken brick, flecks of color thus giving an animated texture to the otherwise leaden and lifeless material. Brushing may be done to greater or less depth, giving a more or less roughened surface, as desired. It is necessary to brush and wash the surface while the concrete is still green, as otherwise the

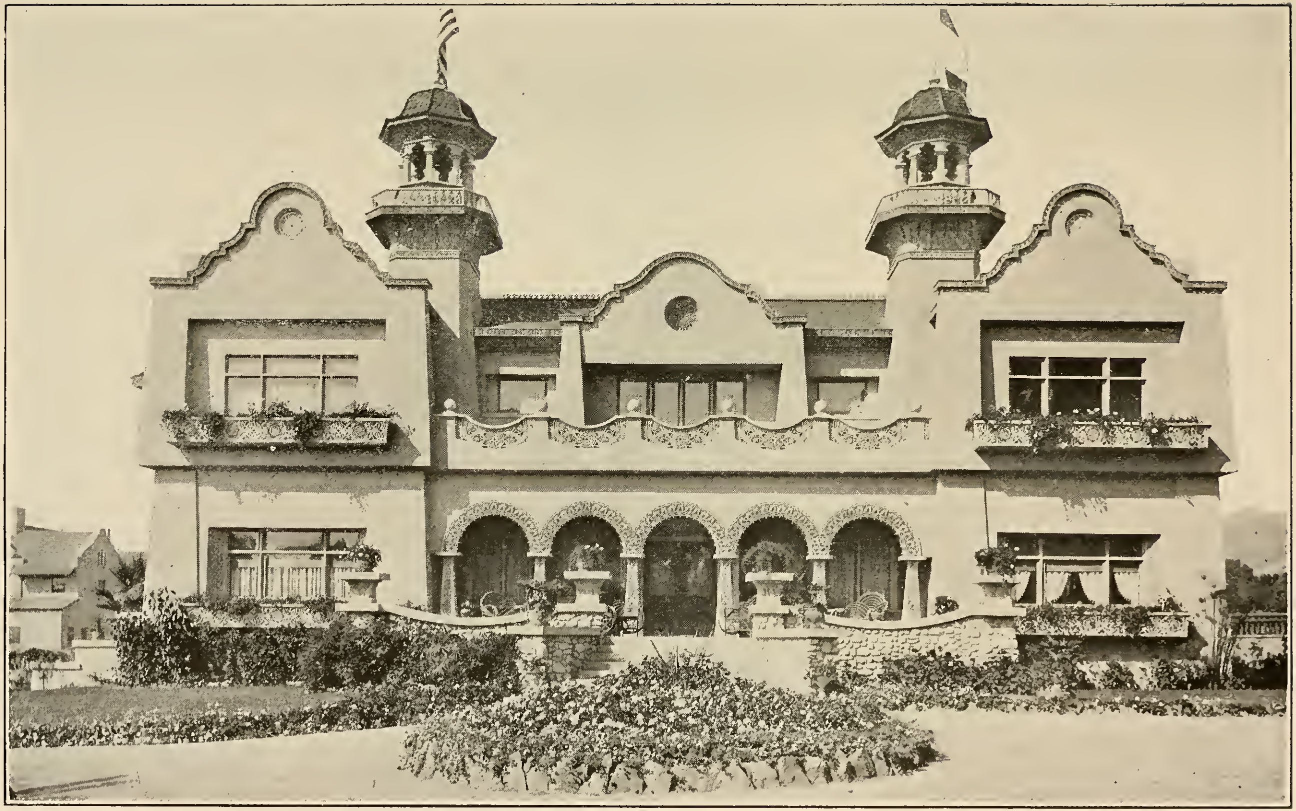

Fig. 5.—An illustration of ornamental iron-work in connection with concrete construction.

process would be too laborious and would be precluded. Therefore the forms must be removed at about twenty-four hours after placing the concrete. The necessity of removing the form work before the concrete has thoroughly hardened considerably limits the practicability of this process. Load-sustaining sections must be hard before the supporting mold is removed from underneath. Where this effect, rather than a smoother finish, is wanted, it should be quite possible to attain it in a measure, even when the concrete is quite hard, by the use of acid and the stone bush hammer. Sufficient of the mortar skin could be removed to obliterate the impression of board veinings and layer marks, and at the same time expose some of the aggregates. After this tool dressing the wall should be brushed down with dilute acid, followed by water played on by a hose to prevent any stains left by the acid.

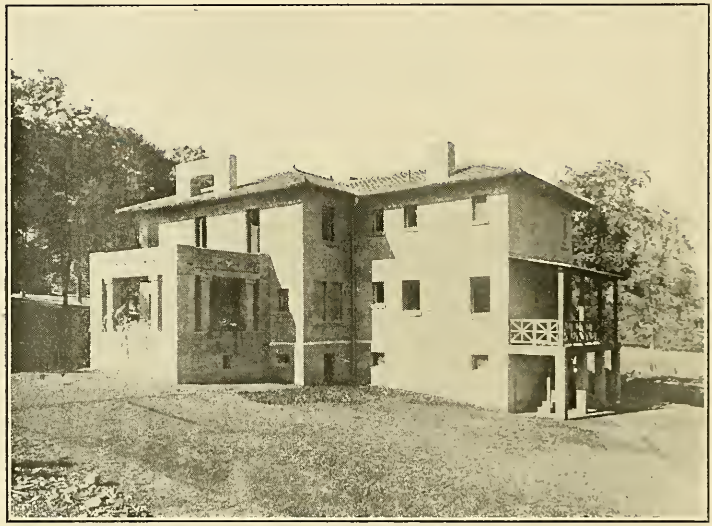

Fig. 6.—An illustration of scrubbed surface, using muriatic acid where the larger aggregates are exposed.

Exposed aggregates produce decidedly the most legitimate surface, the only proper finish, it might even be said, where consistent concrete design and ornament is carried out. As a matter of fact, the method is best suited, for practical reasons, to buildings of small dimensions, and, artistically, to those of simple wall composition. (See Fig. 7.)

In the present transitional period, and quite possibly beyond it, a smoother texture, more nearly that of cut stone, will be considered more desirable for many purposes. Such a finish is arrived at by the method known as *mortar facing*, though it is by no means limited to mortar of the ordinary variety. The most primitive fashion of applying is to trowel on a mortar against the face of the form about an inch thick and for the height of the layer about to be laid and to fill in behind and at once with the ordinary concrete, which, of course, firmly unites with it, as the mortar is still soft. An improvement insuring greater accuracy is to form a slot by means of a sheet-iron plate specially devised for the purpose, with angles to hold it vertically at a desired distance from the face of the forms. The prepared concrete for the facing is first filled into the slot and immediately afterward the backing is poured and tamped down. Then the plate is raised, allowing the two to be firmly bonded together by ramming. When the forms are removed, the facing will require dressing and cleaning down,

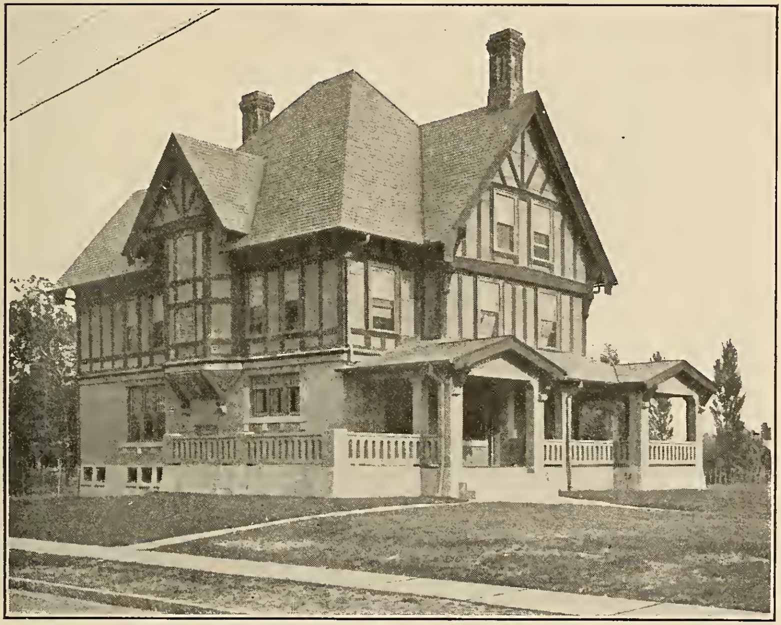

FIG. 7.—A house dressed by hand with the hammer shown in Fig. 18. The different shades in the concrete are formed by the various aggregates used going to compose the same.

as, even though the boards have been covered with oil or soap, the soft material will take the impression of grain and joints, and efflorescence may break out in spots. A great variety of texture, and of color as well, may, of course, be achieved according to the aggregates selected: glistening marble, gray trap rock, yellow sand, and brick dust. (See Fig. 8.)

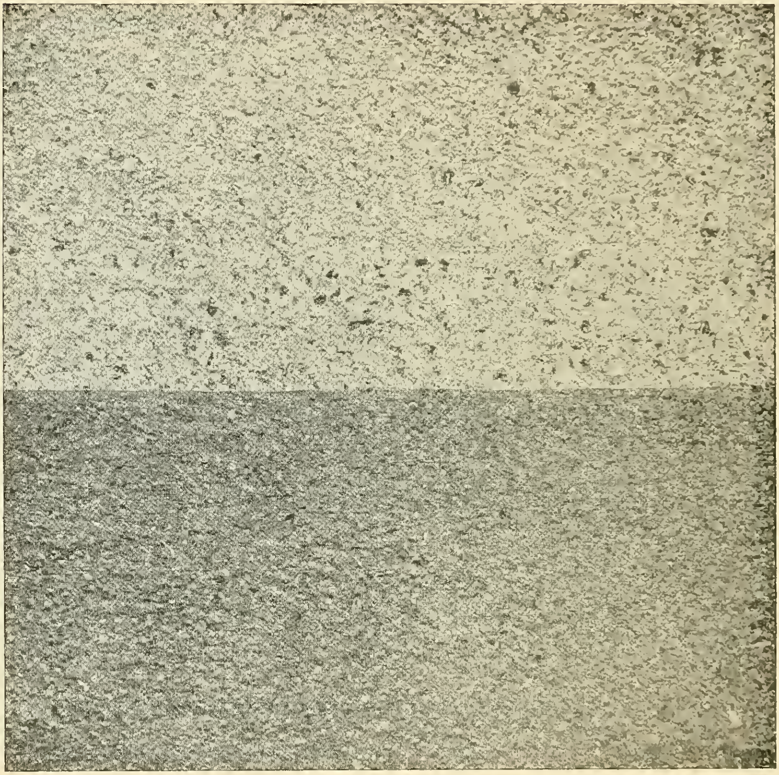

Fig. 8.—Contrast of shades produced by using different colored aggregates. The concrete in the dark portion of this wall was made of red sandstone, while the light portion was made of colored trap rock. The finish of the surface was obtained by hand bush hammering.

A cheaper method, but one not to be recommended, since more permanent finish is possible, consists in applying a skin coat of mortar to the surface after the building is erected and forms have been removed.

The two principal methods above described, respectively that of outspoken concrete, aggregates showing in relief, and the surfaced-finish, displaying an even, fine texture closely resembling that of cut stone, though it may be coarser, are destined, we think, to characterize two schools of design. Each is in its way legitmate, because harmonious with its own set of ideas and adaptable to widely separated classes of buildings.

We must come to the conclusion, therefore, that in the treatment of concrete surfaces one thing is to be borne in mind—that concrete should be treated as concrete and not as a cheap imitation of any other building material. Concrete construction lends itself with great facility to almost any class of surface treatment.

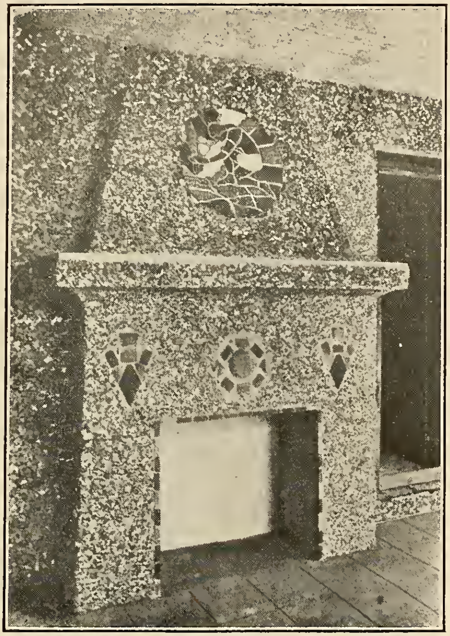

Fig. 9.—A beautiful example of colored clay tile imbedded in concrete. The upper panel has been worked into a picture of an Indian making a fire.

In giving descriptions of a few methods, which have been successfully employed, they can be classed under two general heads: First. by the insertion into the concrete of various colored clays or tiles; second, by placing a selected aggregate, in the nature of granolithic finish, on the surface and afterward scrubbing or otherwise treating the concrete surface itself. Both insertions are made at the time the concrete is placed.

We do not consider in this bulletin the method of treating concrete surfaces by means of placing a veneer of plaster on the outside of the concrete after the forms have been removed.

THE DECORATION OF CONCRETE WITH COLORED CLAY TILE.

By Henry C. Mercer.

When I found the facility with which permanent, weather-proof color could be burned into clay, and realized the tensile strength of the recently improved cement more or less reinforced with iron, I saw how large clay pictures or mosaics could be made, not as in the old Roman method or other previously known ways, by building up the design with minute tesseræ, but by boldly cutting it out of slabs of colored clay. Burn the latter, reassemble the burnt pieces as you would the units of a stained glass window, drop them into a bed of cement and you have a mosaic. (See Fig. 10.)

Because the process lent itself to bold designs on a large scale, and because of the fireproof and weather-proof character of cement and clay, the method appeared particularly well adapted for the decoration of pavements and the inner or outer walls of concrete buildings.

Patterns ranging from 1 foot to 20 feet in diameter, or even where the figures of men or animals might equal life size, consist of pieces of clay burned in many colors superficially or throughout the body, and either glazed or unglazed. The tesseræ, not rectangular as in Roman or Byzantine mosaics, but cut in multiform shapes to suit the potters'

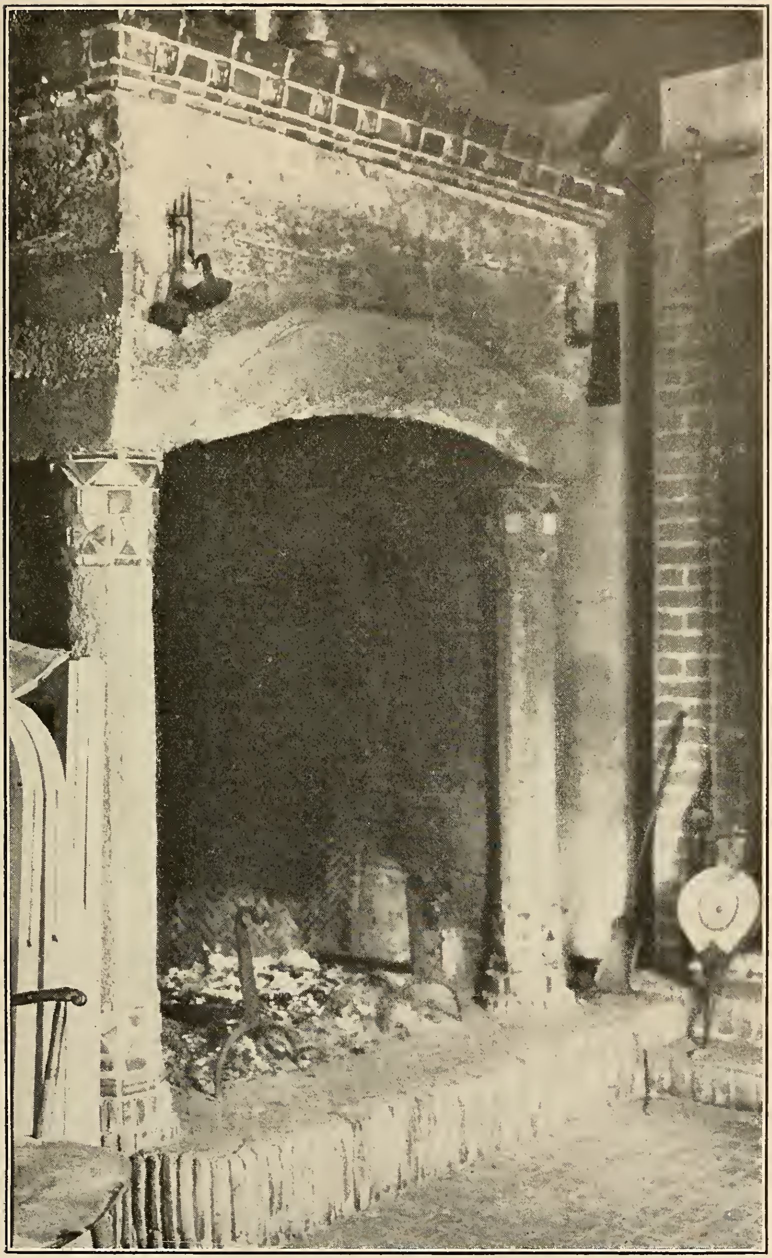

FIG. 10.—A massive fireplace of concrete with decorations in colored clays.

process, and whose contours themselves help to delineate the design, are set in cement at the pottery. Just as in the leaded glass designs of a stained window, bands of lead holding together the glass units form the pattern, so here the cement remaining visible around the circumference of each piece presents the outline of the picture. Thus you have a picture drawn in outlines of cement with clay colors set between the latter. (See Fig. 11.)

From my point of view the complained-of gray of the cement is no misfortune, but a favor. In its neutral color it tones with any hue.

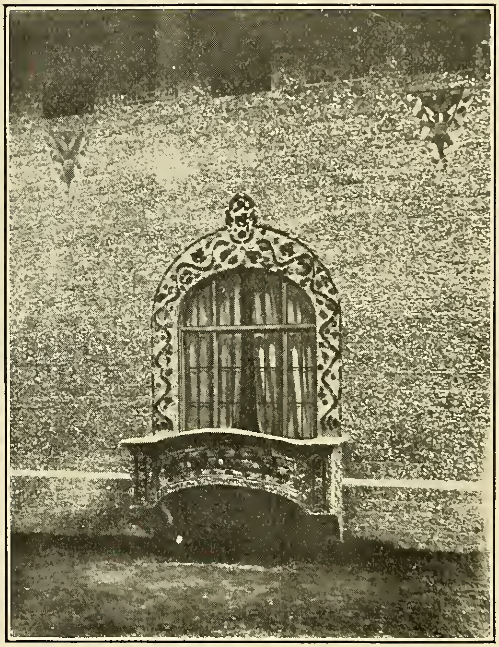

Fig. 11.—By scrubbing carefully selected aggregates beautiful tones are given to the walls. As these are natural colors they fit well with concrete surfaces.

There are several methods by which these clays can be inserted in the concrete.

They can be slabbed in cement in sections at the pottery, and the slabs transported, and placed in spaces left in the concrete as a whole. They can also be laid with their faces against the form and the concrete placed directly back of them. If this is done, a piece of felt should be placed between the form and the face of the mosaic in order to prevent the smaller particles of grout from running on to the face of the mosaic and staining it. They can be set piece by piece in the wall after removal of the form, in which case hollows should be cast for their reception.

In providing space into which to set tiles, nail 1-inch boards, cut to the design on the inside of the forms, before the concrete is put in place. The boards should be nailed lightly, so that the forms can be removed without pulling them from the concrete. When the forms for the concrete walls are removed, these pieces of board will remain in the wall, and should be left in until whatever surface finish is desired for the remainder of the wall has been completed. They are then removed, thus leaving recesses 1 inch deep, conforming to the design, and the tiles are placed in these recesses, being cemented in with a

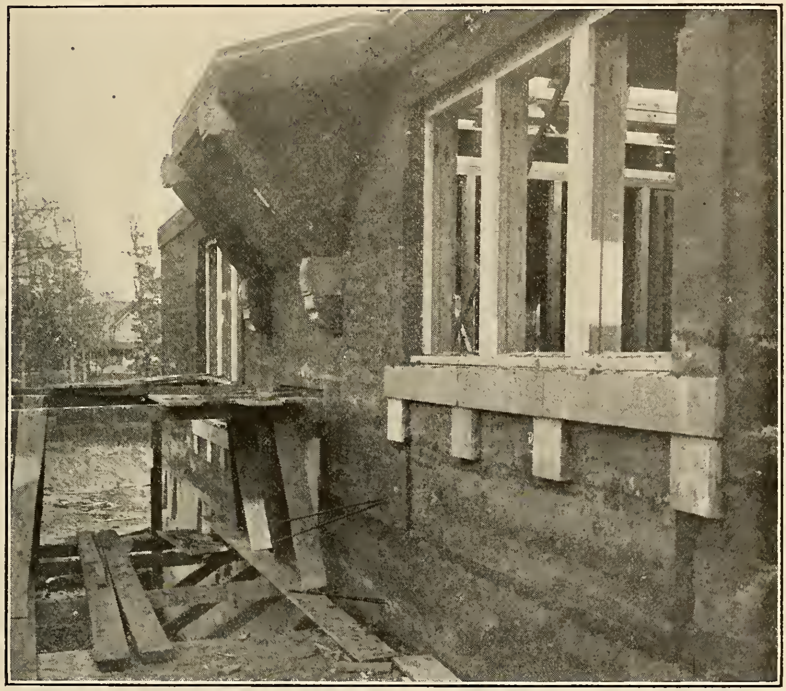

FIG. 12.—Concrete surface as it appears when forms are removed. Under the bay window a panel is formed in the concrete in which the colored clay tiles are inserted.

mortar, varying in color to conform with the design. Panels of any size may be made in this way.

Tiles can be cast direct into a pavement or ceiling. In the latter instance lay the pieces face down on the mold. Then, when the concrete is poured over the clay pictures, they became an integral part of the building itself.

Decoration by Surface Treatment—Use of Carborundum Stone.

The original idea of monolithic concrete surface finish was a very smooth effect in the nature of a concrete sidewalk. This was accomplished by troweling, but was found to be poor from an artistic standpoint, and also the over-troweling of the surface (very likely to occur) caused the same to crack. By the use of a carborundum stone the same effect may be produced and the surface will not crack. After the forms are removed the concrete must be thoroughly wet with a brush and then rubbed with a coarse No. 16 carborundum stone. Bring the surface to a lather. After this stone has been used sufficiently to take off the rough projections, the lather must be washed off with a brush and the concrete again wet, and then dusted with a mixture of dry sand and cement, the proportions being one part of cement to two parts of sand. This is then rubbed into the surface with a coarse No. 16 stone. Care must be taken not to allow any of the mortar to remain on the surface. The final finish is obtained by rubbing the whole surface thoroughly with a No. 30 carborundum stone. This finish gives a lighter colored surface than troweling, fills in any pores that may be in the cement coating, and leaves the masonry more waterproof than it was originally.

Treatment by Scrubbing.

We come now to the second method of concrete surface treatment, namely, the removal of a certain part of the concrete wall to expose other parts of same, and in this way furnish more life and feeling. Either the small aggregate, that is, sand, or the large aggregates, together with the smaller aggregates, that is, the sand and the stone, may be exposed by this method. There is a slight difference in the placing of the concrete, depending upon whether the large or small aggregates are to be exposed.

In case the smaller aggregates are to be exposed, the concrete should be carefully spaded between the concrete and the surface in the form, as this brings to the surface finish particles of sand and the cement itself.

In case the larger aggregates are to be exposed, no spading should be done, but all the tamping of the concrete should be done in the middle of the wall. This causes the pushing of the larger aggregates (stones) against the surface of the form. In either of these methods the desired color effects come from the color of the sand or the stones used in the concrete. These stones should be very carefully selected, with the ultimate color effect to be obtained constantly in mind. The same selection of aggregates should be used throughout the entire wall, so as to give it a uniform variety of color. If white limestone is used for one batch of concrete and trap rock the next, the wall would be covered with ugly blotches of alternate black and white, and would present a far from pleasing appearance.

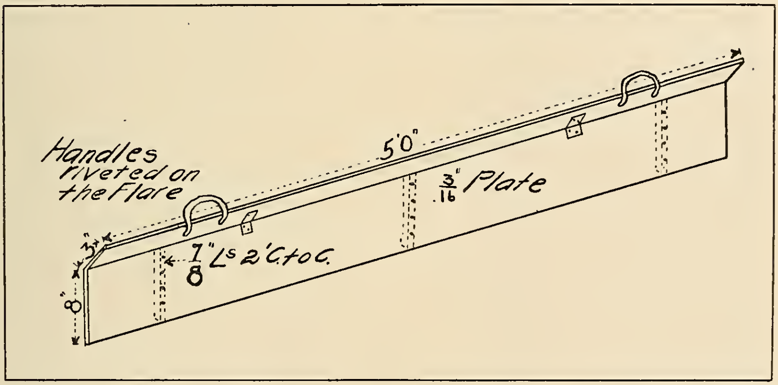

FIG. 13.—A simple implement for placing any combination of aggregates for a face at the same time the concrete is placed.

The forms should be removed within twenty-four hours of the placing of the concrete and the surface scrubbed with an ordinary scrubbing brush or wire brush and water, until all the mortar is removed from the surface of the aggregates and their natural color exposed to the eye.

It very often happens that it is inconvenient to remove the forms in so short a time, and if they are left longer the same results may be obtained by the use of a solution of one part muriatic acid to four parts of water. If this solution is used, the whole surface should be finally washed down with water to remove any particles of the acid remaining on the concrete.

A very successful method, by which practically any color of surface finish can be obtained, is the insertion of a metal frame between the concrete and the surface of the form. This can be done in several ways. The one most generally employed with uniform success is to run a line of sheet-iron forms, each 12 inches high and 6 feet long, across the face 1 inch away from the outside forms. (See Fig. 13.) These forms, or "granolithic" plates, as they are called, are held away from the face forms by 1-inch angles riveted vertically on the plate. The plates are allowed to lap each other and several small

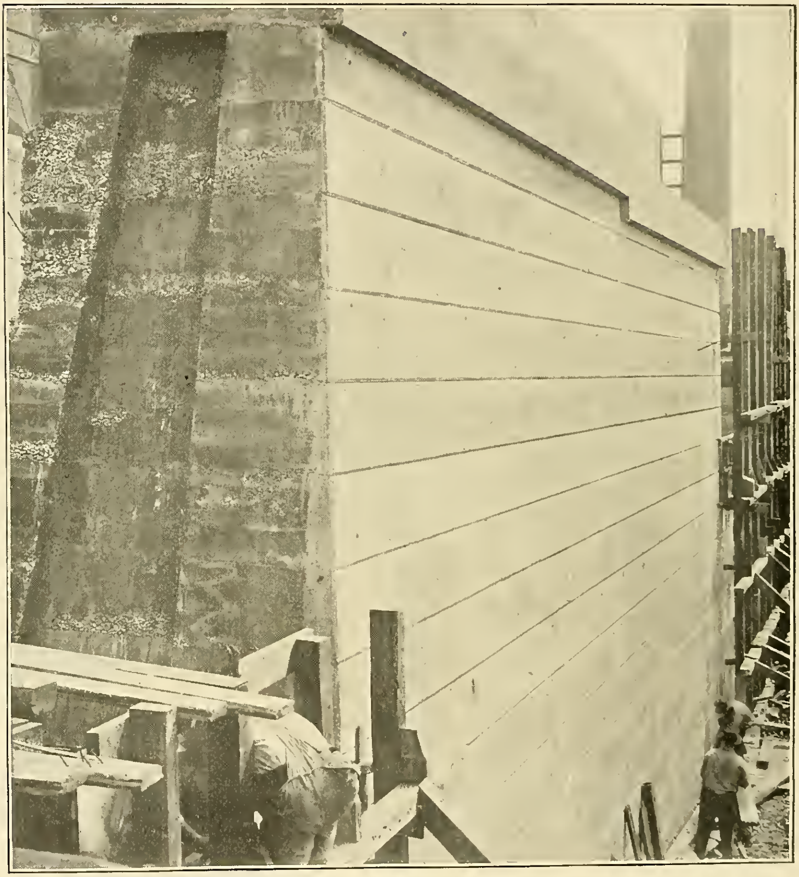

Fig. 14.—Showing a wall in which selected aggregates form a coating of about three-quarters of an inch. The surface will never peel off, as it is placed at the same time the wall is built.

plates are used to fill out evenly the length of the form. The top 3 inches of the plates are bent backward away from the face to give sufficient room to pour the granolithic mixture between it and the face forms. The concrete and the finishing mixture are poured at the same time, the latter always being kept slightly higher than the former. This prevents any of the concrete itself or cement grout from running between the lap in the plates and down onto the face of the work, as this would disfigure it. The granolithic finish is mixed wet and poured from a bucket into its place. As the work proceeds the granolithic places are raised so that their top edge is always 6 inches or 8 inches above the concrete. This can be done very easily when the concrete is laid in 6-inch layers. (See Fig. 14.) Twenty-four to thirty-six hours after the concrete has been placed the forms are taken down and the surface washed down to remove the sand and cement from between the grits, allowing the latter to stand out and present a very good imitation of granite finish. After washing, the wall is protected from the sun and wet down twice a day for the next

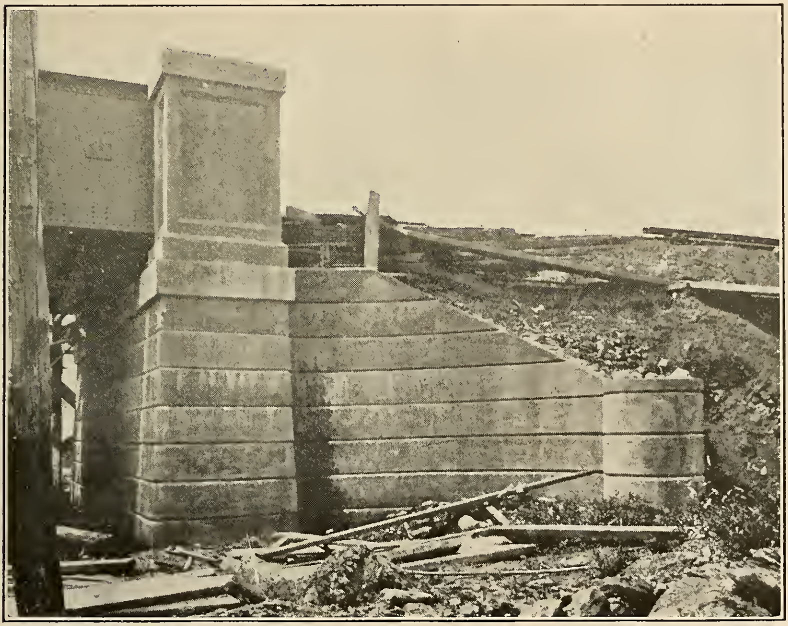

FIG. 15.—An illustration of scrubbing, where the small aggregates are exposed.

three days or longer, depending on the condition of the weather. In washing down, if the washing is started within twenty-four hours of the placing of the concrete and the forms removed so as to expose only about twenty to thirty minutes' work ahead of the scrubbers, then an ordinary bristle scrub-brush will work very well, and very rapid work can be done. If, however, the surface is not scrubbed until thirty-six hours after the placing, or is allowed to stand several hours after the forms are removed, then the scrubbing becomes very difficult, and it is necessary to use a wire brush and only slow progress can be made. In any case a constant stream of water is kept running down the portion of the surface being washed. Some care has to be exercised to make the scrubbing uniform, as too much or too little pressure on the brush will make considerable difference in the appearance of the finished surface. The scrubbers soon get accustomed to this, however, and learn to vary the pressure with the state of hardness of the surface. Fig. 15 shows how effective this method of finishing a concrete surface can be made.

By varying the mixture of the granolithic finish practically any color and texture can be obtained. By the use of white cement and crushed marble a beautiful white appearance is secured; by the use of ordinary cement and crushed brown stone, a dark brown effect is given. Marble flour with ordinary cement gives light gray. Crushed red granite gives a permanent and attractive color.

Coloring-matter.

Coloring-matter mixed in mortar is sometimes used to give a uniform color to the entire wall. The cement, sand, and coloring-matter are mixed together dry, and it is advisable to experiment a little to find how much color is needed to give the desired shade. The mortar will appear several shades darker while wet than after it has dried.

By mixing five pounds of coloring-matter with a bag of cement, the following colors are obtained:

Raw iron oxide will give bright red.
Roasted iron oxide will give brown.
Ultramarine will give bright blue.
Yellow ochre will give buff to yellow.
Carbon black or lampblack will give gray to dark slate.
Manganese dioxide will give black. (Use eleven pounds per bag of cement.)

A mixture of equal parts of carbon black and red iron ore gives dull reds. In all cases the addition of mineral colors causes a loss of strength, but this is not important, since the color is used only in the surface coat. Lighter shades may be obtained by using one-half to one-third the quantities of coloring-matter given above.

The additional expense of coloring a surface layer $\frac{3}{4}$ of an inch thick will vary from half a cent to two cents per square foot.

It will be seen that any desired color may be obtained by varying the color of the aggregate or by the assistance of mineral coloring-matter.

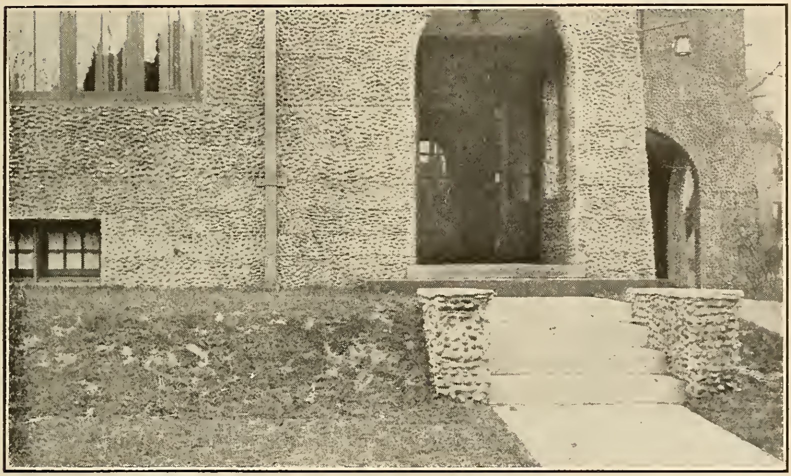

Fig. 16.—Showing how strongly pebbles placed in clay in the forms show up after the clay is washed away.

Clay Treatment.

If a treatment of artificially exposed aggregate, sometimes called pebble dash, is desired, the following method may be employed:

Erect forms of rough boards in usual manner, in courses of 3 feet or less. Plaster inside these forms with wet clay. To this wet clay apply different colored pebbles in sizes of $\frac{3}{4}$ inch down to those that will be retained on $\frac{1}{4}$-inch screen. The pebbles will stick to the clay. Pour in the concrete and remove the forms in the usual time, and after the concrete has become thoroughly set wash off clay with a hose, scrubbing slightly with a brush. The clay will tint the concrete and the pebbles will give a pleasing color effect. (See Fig. 16.)

Any colored pebbles desired may be used in this way, and in a number of places pieces of broken glass have been embedded in the concrete.

Bush Hammering.

For wall work the surface is sometimes picked with a pointed or toothed tool. This chips off the mortar which may have flushed to the surface and cuts away little particles of the mortar from the aggregate below. The roughening of the surface breaks up the light, gives a lighter, snappier color to the mortar itself, and besides this exposes the color of the aggregate below. Oftentimes where gravel is used the stones show rusting and have various shades of browns and reds. This additional color on the concrete adds a great deal to its appearance, and when the dressing is carefully done it gives as pleasing a surface as can be obtained economically. The dressing removes most of the traces of the form and does away with inequalities which may occur in the work. (See Fig. 17.)

The objection to this kind of dressing comes in the removal of the surface mortar, which is the most waterproof part of the concrete. If there is any tendnecy toward porosity in the mass of concrete, it will absorb more moisture after the dressing than before it, and will accentuate the injury from frost. On well-handled and properly proportioned concrete there is, however, very little danger from this, as the material is of itself very dense and waterproof. The fence around Soldiers' Field in Cambridge, in 1899, was treated in this way. It is in low land along the river, where it is fairly damp. This wall is exposed fully to the weather and is in thin sections, but there is no surface deterioration from the weathering.

This rough picking shows the masonry honestly as concrete, without any imitation of other material. It gives a pleasing surface and one that can well be used on building work. A fairly good Boston example of this dressing is the little subway station on State Street, near Atlantic Avenue. A comparison of the appearance of this dressing and of stone surface is readily afforded by the other subway stations. A laborer with a hand-pick will dress from 40 to 50 feet of concrete surface two to three weeks old in a day. With a pneumatic tool laborers will get over 50 to 60 feet. There is but the slightest difference between the work of the hand tool and the machine tool. The depth of the cutting and the fineness of it can, of course, be varied to suit the conditions. This is the surface that the architects use generally for their landscape and other ornamental work. From the point of economy as well as good looks, this dressing for wall surfaces deserves attention.

Two methods of bush hammering have been successfully used in the preparation of concrete surfaces, viz., hand hammering and hammering with an air tool.

In hand hammering the concrete should be allowed to stand at least three weeks after placing, and the longer time given it, up to three months, the more artistic will be the result of the surface. This is due to the crystallization of the cement. In three months it becomes practically as hard as the stone going to form the larger aggregate, and the stone, as well as the cement, is broken by the bush hammer, thus giving life to the surface. In case the concrete is left for longer than three months, the bush hammering becomes very difficult, as the concrete gets so hard that hand hammering has very little or no effect upon it. Various weights and sizes of hammer have been used. A nine-pound hammer with thirty-two points on one end and twenty-five points on the other, and also the same weight hammer with twenty-five points on one end and sixteen points on the other, have given good success. The tendency, however, seems to be toward having a lesser number of points with a lighter hammer. The illustration (Fig. 17) shows the result of a three-pound hammer with

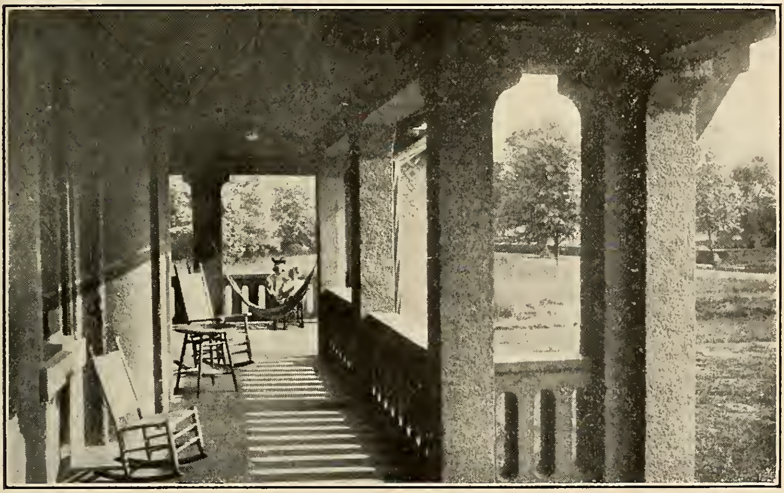

FIG. 17.—Porch columns and balustrade finished by bush hammering.

four points. The points are pyramidal in shape and are two-thirds of an inch apart.

The cost of the bush hammering on this house was from two to three cents per square foot of surface. This is exclusive of the cost of scaffold.

Bush hammering with compressed air has been very effectively used on engineering structures of larger magnitude, where compressed air was available. The Connecticut Avenue Bridge, Washington, D. C., and the Walnut Lane Bridge, Philadelphia, are examples of this method of treatment. The texture of the finished surface very closely represents that of granite.

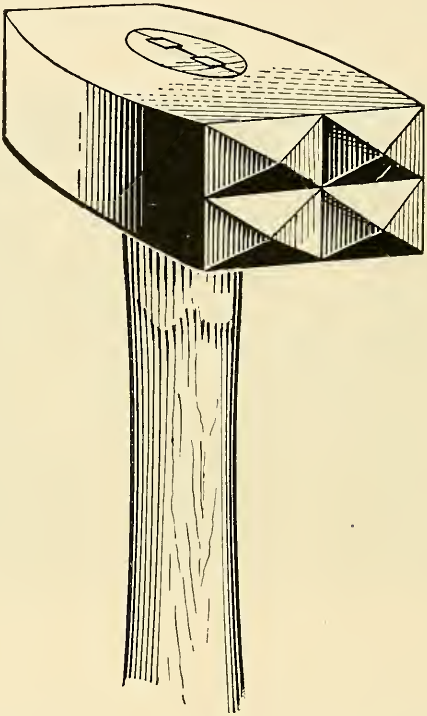

Fig. 18.—A tool successfully used for hand dressing at house near Philadelphia.

The few methods of surface treatment given here are of necessity briefly described. Our intent has been to point out the possibilities of surface treatment, giving some few examples of work successfully completed, but to leave to the imagination of the owner or architect the particular combination of colors or surface according with the designs of the houses.

One of the original objections to the use of concrete in house construction was its supposed lack of artistic possibilities, and many yet are of that opinion. If I have succeeded in clearly showing the possibilities of artistic treatment, the object of this article will have been attained.

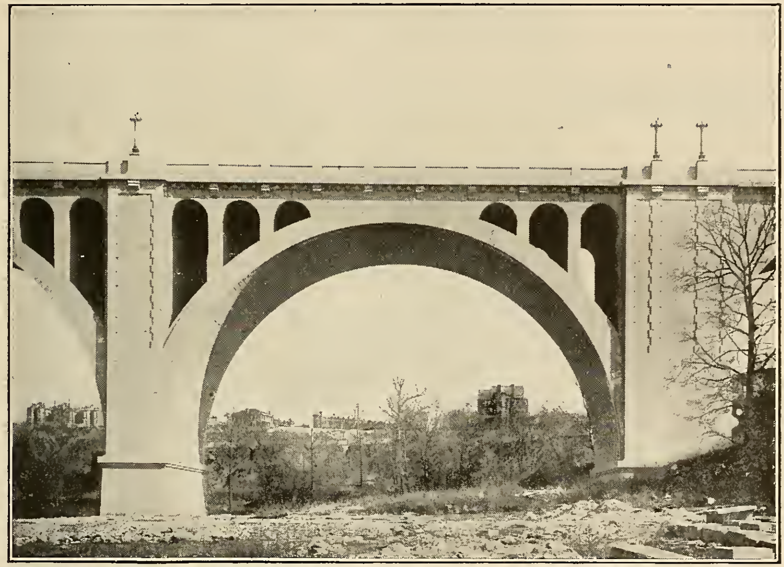

FIG. 19.—One of the largest concrete bridges in the United States, where effective surface finish has been produced by pneumatic tool hammering.

Sand Blast Finish.

The exposed aggregate effect can also be obtained by what is known as the sand blast finish. This, as its name implies, consists of impinging sand by means of compressed air against the surface of the concrete. This removes the outer skin of the material in much the same manner as scrubbing, and for extensive operations this method proves very economical.

Fig. 20 (page 28) shows a gang at work on the balustrade of a bridge. This method produces results very rapidly, and the effect of exposing the aggregates and bringing them into relief gives a very artistic surface.

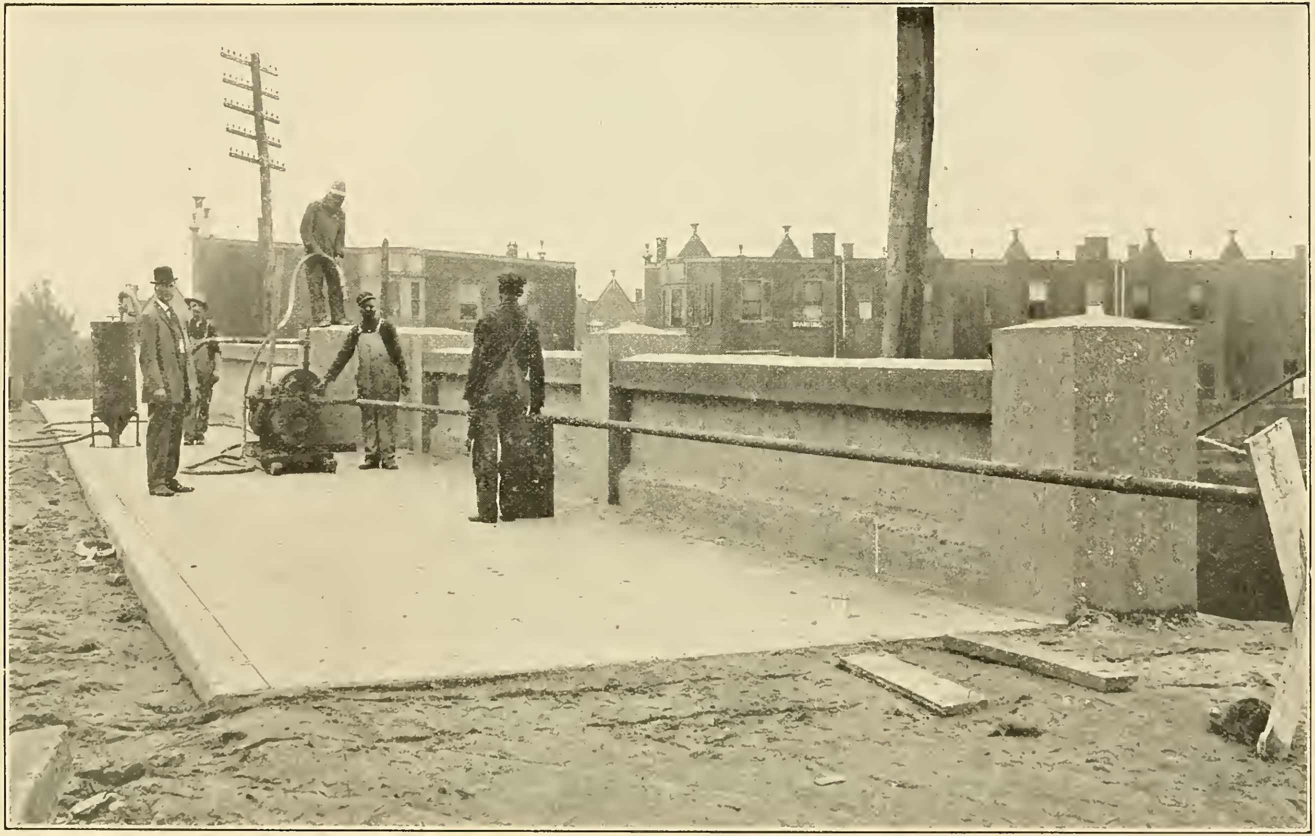

Fig. 20.—Method of finishing concrete surface with sand blast.

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Concrete Tile
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Concrete Tile for Land Drainage

Are there any slacker acres on your farm—fields too wet for cultivation, covered with stagnant water? Are there sloughs or swales where crops drown during periods of heavy rainfall—acres where nothing is raised but frogs and mosquitoes?

Through tile drainage, hundreds of thousands of acres of such land have been made into some of the most productive farms in the United States.

Example of necessity for drainage. Pipe distributed ready for laying and machine about to start trench. This land has become so clogged from lack of drainage that weeds grow better on it than corn

Benefits Derived From Land Drainage

Larger crop yields, greater assurance of crops and larger profits are some of the direct results of land drainage. From the standpoint of land drainage, water in the soil is considered from two viewpoints: Water which is drained away is known as gravity or hydrostatic water. It retards plant growth. It is the excess water which tends to flow downward under the action of gravity. Capillary water in the soil keeps it moist and supports plant growth. It rises in the soil just as oil rises in a lamp wick. Land drainage removes water which is injurious to plant growth, but none of the water that is necessary and beneficial.

Drainage Assures Longer Growing Season For Crops

Soil that has been systematically drained is in condition to cultivate ten to twenty days earlier in the spring than undrained land because surface and excess water will disappear as soon as frost leaves the ground. Soil will also be warmer because air will enter it and warm it up after the water has been removed. Seeds will therefore germinate sooner and young plants will grow more rapidly. On undrained land the farmer must wait for excess water to evaporate. This process takes heat from

Land in Black Prairie belt, Ala. Typical cotton crop of only two to six bales of cotton on twenty acres because land needs drainage

the soil which should be retained to give young plants an early start. This accounts for the slow growing, sickly looking, yellowish plants that are seen on water-logged soils during early spring. Getting an early start gives corn more time to mature before fall frost. Small grains also have time to fill and ripen before the hottest weather sets in.

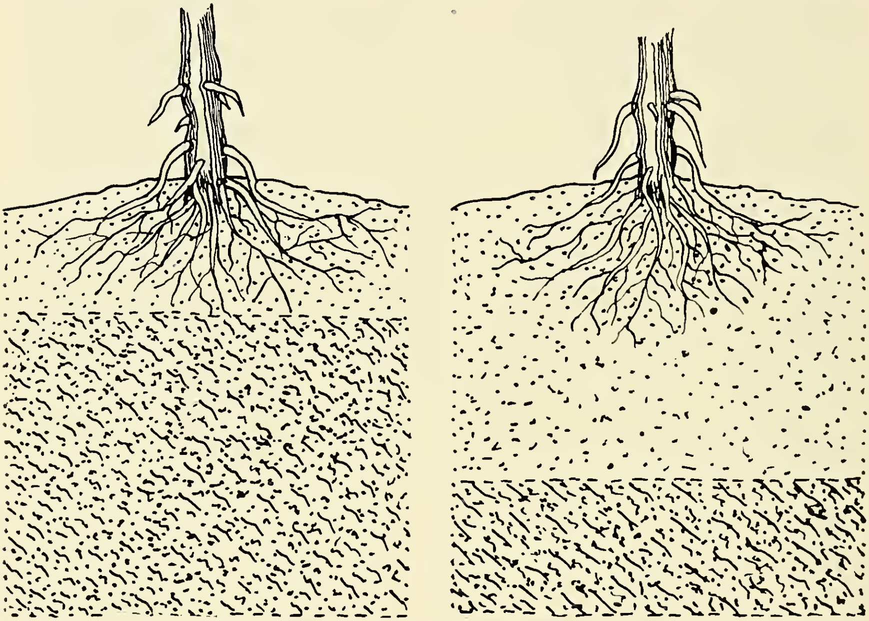
Drainage Increases Source of Food Supply For Plants

When surplus water clogging soil pores is removed, air enters the soil. This is necessary to help liberate plant food and to stimulate plant growth. Deeper root penetration is encouraged and made possible in a drained soil. Plants thus have a larger supply of plant food to draw from. Deep rooted plants will not be affected by drouth so much as shallow rooted

The same land shown in the preceding picture after drainage. Productiveness increased to twenty-six bales of cotton on twenty acres ones. For this reason, drained land is more drouth-resistant than undrained areas.

Physical Condition of Soil Improved By Drainage

Drainage opens the soil, makes it more porous and permits air to enter with greater freedom. Plant root systems are thereby enabled to spread and develop to their fullest capacity. A porous soil will retain more capillary moisture than a dense soil. Drained fields are easier to cultivate because the soil being porous is easier to work. Drained land does not "bake" nor "crust" on the surface as readily after heavy rains. It can also be cultivated much sooner after rain.



Sections showing undrained soil—at left in spring, at right in summer. High water level in spring prevents development of plant roots. Summer water level too low

Soil Erosion Reduced By Drainage

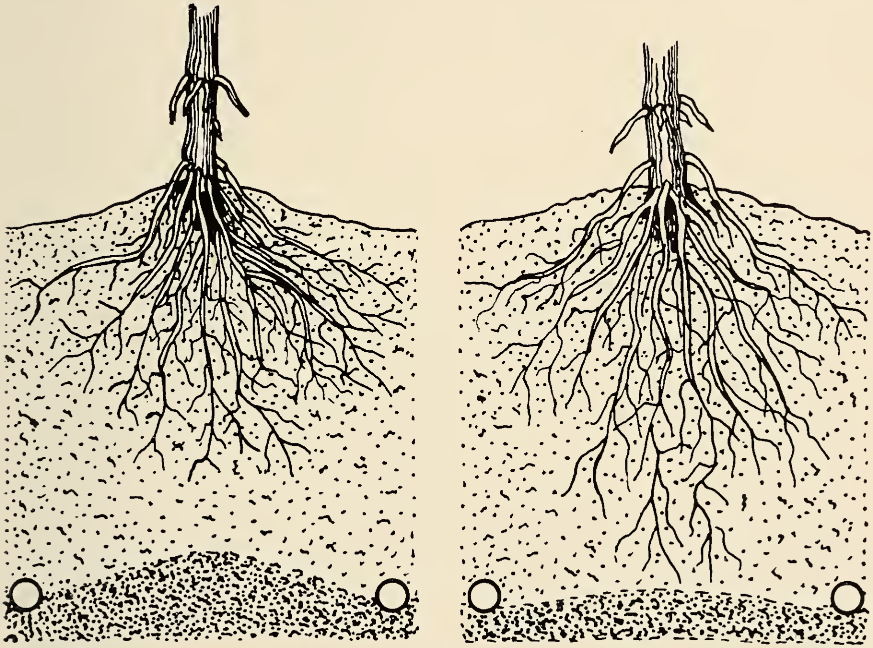
On drained land surplus water from rainfalls will soak into the ground and be led away by the tile drains. Surface washing is thereby largely prevented. On undrained lands soil fertility is washed away and deep gullies cut in the fields.

Sanitary Conditions Improved By Drainage

With no standing water, mosquitoes have no favorable breeding ground, so malaria does not prevail. Evidence of increased healthfulness of a community resulting from drainage is plentiful. Investigations conducted by the Indiana Bureau of Statistics based on the study of the effects of drainage in one township show what drainage may be expected to accomplish from the health standpoint. According to doctors' reports from this township, there were 1,480 cases of malarial diseases in the five years preceding drainage, while during the five years following drainage only 490 such cases were reported.

Profits of Tile Drainage

From the investment standpoint, tile drainage can hardly be equalled. Returns in increased crop production and increased land values will quickly repay the entire cost of having tile laid. Land that cannot be cropped because it is too wet is a constant expense to its owner. He has money tied up in it, must pay taxes on it, or may be paying interest on a mortgage and in return receives nothing except perhaps a good crop of useless weeds. Investigations of agricultural experiment stations prove conclusively that tile drainage may be expected to pay for itself in from one to three years, in terms of increased crops. Making land more productive will also increase its selling value by more than the cost of installing the drainage system.

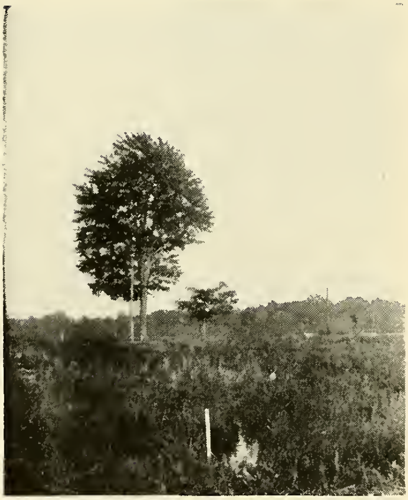


Sections showing drained soil—at left in spring, at right in summer. Tile retains a constant water level throughout the life of the plant

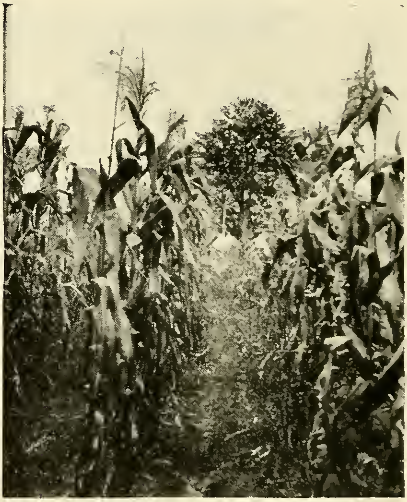
In an investigation to determine the value of tile drainage, the Oregon Agricultural Experiment Station sent out circular letters to farmers in Willamette Valley and asked these questions: Do you consider that drainage pays under your conditions and can you name any definite results? Every answer to the first question was "yes," some going farther and adding "Decidedly," "Certainly" and "It pays big."

The following are some of the typical replies received to the second question:

> "The land is dry enough to farm and produces good crops where before draining it was waste."
>
> "Yes, one half of the field could be used only for spring crop and then dried out hard as a bone. Now with drainage it is better than the other fields."
>
> "Yes, land that formerly did not pay taxes now produces good crops. I consider the tile has doubled the output of the farm and the system is not yet completed."
>
> "After the soil is thoroughly drained it becomes very porous and will hold capillary moisture fully 100 per cent better. The soil becomes warm and the roots of crops can penetrate the soil to a greater depth."
>
> "Yes, where once there was a swamp, I now raise 50 to 90 bushels of oats to the acre."
>
> "Indeed, I have drained my land with success. I would rather have 160 acres drained than 320 undrained, if I had to live on it and farm it."



Undrained land, Talbot County, Md., 1911



Same land after drainage, 1914

Investigations conducted by other experiment stations brought forth replies or data equal in praise of tile drainage. The Missouri Agricultural Experiment Station published in its Bulletin No. 118 some general conclusions based on data secured from farmers who have tile drainage in that state. The following are representative of replies received:

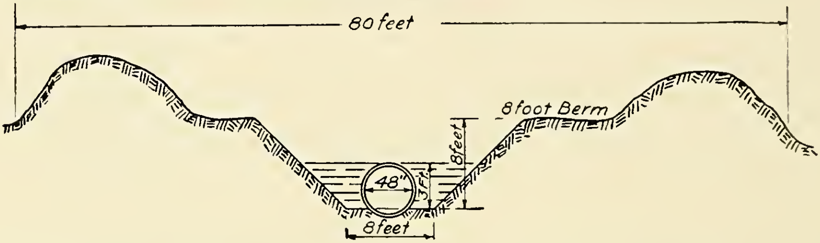
> "Land too wet to raise good clover was tiled in 1909. In 1912, raised an oat crop estimated at 50 bushels per acre. Best over the tile. Land is firmer in wet seasons and can be plowed earlier in the spring. This tiling worth $50 per acre."
>
> "Land so wet that it was not plowed for 11 years was tiled and now yields good corn crops."

> "Tile laid in a creek bottom through a number of low places which were never dry enough to farm more than one year in seven. The best crops are now raised in these soils."
>
> "Soils covered with water the entire year were quite successfully drained. The first crop paid all expenses."
>
> "A field considered the flattest, wettest and poorest in this neighborhood was tiled and now cultivates like an entirely different soil. It is more friable and can be plowed much earlier than formerly. Tile paid for itself the first year."

Open Ditches Objectionable

Early methods of land drainage usually followed the practice of digging open ditches and laterals. Experience has proved such methods of attempting to lead surplus water away are very unsatisfactory. As a rule, open ditch drainage systems in flat country do not have outlets low enough to reduce the water level in the soil. Water simply stands in the open channels and not all possible benefits of land drainage are secured, although flood water is led away. Because of the space occupied, open ditches prevent cultivation of much land. They also must be cleaned out perhaps several times a year to keep them in working order. Naturally they must follow more or less closely different slopes of the land, so they cut fields up into irregular patches, making cultivation more difficult and expensive. With fields all cut up in this way, easy movement of farm machinery or equipment from one field to another is impossible unless small culverts are built over trenches, and bridges are built

Open channel showing large area of land withheld from cultivation by progressive soil erosion over large ditches. Still more objectionable however than the foregoing is the fact that rapid soil washing and gullying of the ditch during heavy rainfalls soon completely destroys the ditches and removes more land from cultivation. Ditches and trenches prevent cultivation of strips of land close to their edges. Therefore strips along these open channels soon become weed beds. Open ditches also frequently become stagnant and offer excellent breeding places for mosquitoes.



This diagram illustrates the amount of land withdrawn from profitable cultivation where open ditches are used. In this view it is shown how a 48-inch concrete pipe will replace a ditch eight feet wide at the bottom and carrying three feet of water, thus permitting cultivation of a strip of land eighty feet wide otherwise entirely lost

Replacing the Large Open Ditch With Concrete Pipe

The diagram shown on this page illustrates how readily concrete pipe 48 inches in diameter can take the place of an open ditch that keeps out of cultivation a strip of land approximately 80 feet wide. It is never certain that an open ditch will always confine its path to a strip of the width mentioned. During heavy rainstorms more soil may be washed away. Each year this washing and soil erosion makes the open ditch less effective and more of a nuisance and expense.

Loss Caused By the Open Ditch

Why should any farmer be deprived of the income that could be obtained from farming an 80-foot strip running across his farm? Such a strip means an acre of land every 544 feet. Such a strip running 80 rods through one farm means 2.43 acres lost. If the land is worth $200 an acre, there is an investment of $486 that not only is paying no profit, but eating up money year after year in taxes and interest on the money invested. Land worth $200 an acre should earn at least 5 per cent or $10 an acre. In 50 years this loss for 2.43 acres is $1,215, which represents actual cash taken out of the owner's pocket. In reality the loss is more than this because the value of the land is lost and the taxes are lost.

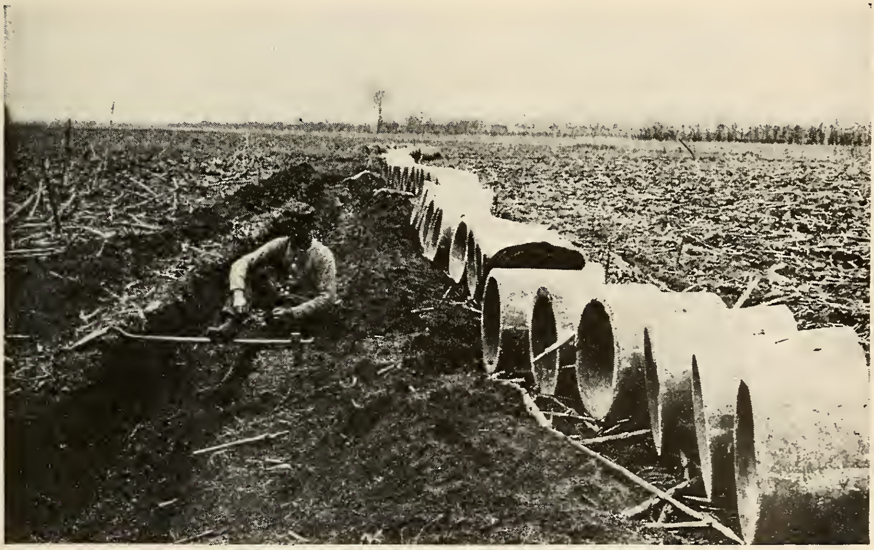
Many persons have been surprised to know how large an open ditch can be successfully replaced by concrete tile of comparatively small diameter. Only in those cases where a drainage project may involve reclaiming vast areas of flat lowlands and where the volume of water to be handled exceeds the capacity of the largest sizes of concrete pipe obtainable should the open ditch be considered. Careful measurement of the quantity of water flowing in many open drainage channels will prove that the ditch was merely an apparent necessity, not a real one.

DRAINAGE SYSTEMS SHOULD BE CAREFULLY PLANNED

The following paragraphs taken from the 1914 Year Book of the United States Department of Agriculture draw attention to a number of very important points which should be given careful consideration when planning and carrying out a drainage system:

"A careful business man in making investments considers security first and dividends afterwards; it is the gambler that takes chances, risking in play for high stakes. The man of small capital least of all can afford to expend money without certainty of the returns, yet it is he who most often economizes by undertaking drainage work without expert assistance. The wonder is not that a considerable amount of money spent for drainage has been lost, but that so much of it has been profitable. To determine the most economical plan of drainage usually requires engineering judgment of no mean order and a thorough knowledge of the drainage properties of soils. One not experienced in this kind of work should not take the responsibility of planning any considerable expenditure for drainage. There are many farm owners that realize the need of drainage but have not the means to do a great deal of work at a time, and therefore are loath to pay for the services of a drainage engineer to determine what work is needed, and to plan it so that it not only will cost least in the end, but also can be constructed in an orderly and economical manner.

"Before other expenditures are made there should be a careful survey and examination to determine the source of the water to be removed and its amount, the most economical arrangement of the drains, the grades obtainable and the proper sizes of drains, and the amounts of tile and



A carefully planned drainage system under construction labor. The cost of drainage can then be estimated quite closely by one acquainted with work of this kind. Sometimes only a few drains are needed in the lowest parts of the field; sometimes a uniform system is required with parallel lines underlying the whole area. In the latter case experienced judgment is needed to decide what will be the proper depth and spacing for each kind of soil.

The Work Must Have Proper Supervision

"Construction work should be carefully done, under the supervision of some one at least qualified to see that the tile are laid according to the grades established by the engineer who planned the work. The tile must be laid to true grade and alignment, for very slight irregularities will retard the flow and permit dirt to fall into the drain. Many a drain has been choked by sediment deposited very gradually in a slight sag which could hardly be detected by the unaided eye. The employment of a competent drainage engineer to plan the drainage system and to supervise construction in the end will be the most profitable part of the investment."

Concrete drain tile in cement products plant storage yard. Such tile are proof against destruction by frost

Undrained land is a drain on your purse
Let concrete tile convert your loss into a profit

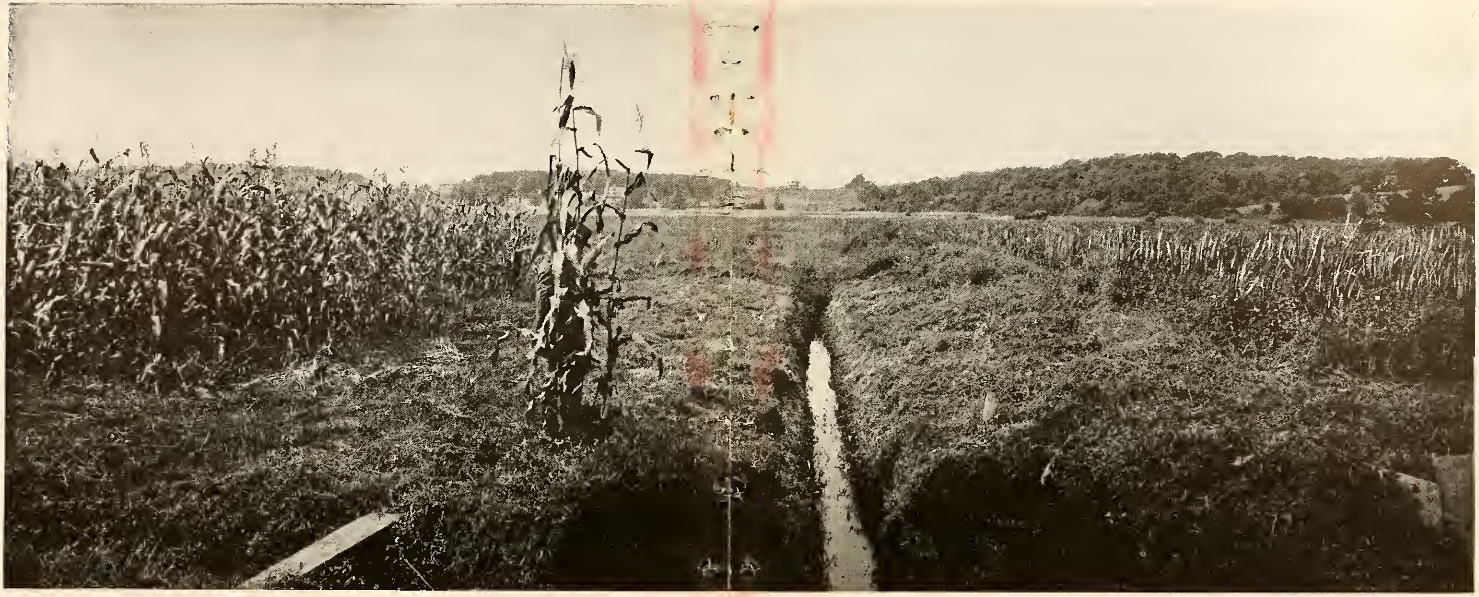
Table III.

Figures used in Iowa in 1922 for estimating cost of digging trench, laying tile and backfilling.*

Diameter of Tile Inches	Cost *per foot of depth one rod (16½ feet) long* of digging trench, laying tile and backfilling.					
	3 to 5 Ft. Deep	5 to 6 Ft. Deep	6 to 7 Ft. Deep	7 to 8 Ft. Deep	8 to 9 Ft. Deep	9 to 10 Ft. Deep
5–6	$ .22	$ .30	$ .35	$ .46	$ .57	$ .70
7–8	.28	.33	.40	.50	.60	.70
9–10	.32	.40	.45	.52	.61	.71
12	.34	.45	.48	.52	.61	.71
14	.38	.46	.52	.57	.62	.72
15–16	.42	.51	.56	.63	.70	.80
18	.48	.56	.62	.67	.74	.87
20	.53	.62	.67	.72	.80	.90
22	.63	.70	.75	.80	.90	1.08
24		.78	.83	.94	1.09	1.35
26		.86	.95	1.10	1.17	1.56
28		.94	1.10	1.35	1.57	1.87
30		1.11	1.36	1.51	1.81	1.90
32		1.40	1.57	1.71	1.92	1.95
34		1.70	1.81	1.93	1.97	2.09
36		1.75	1.90	1.99	2.40	2.60

The following examples may be helpful in explaining how to use the above table. Suppose it is desired to estimate the cost of labor for digging one rod of trench 6½ feet deep and large enough for tile 16 inches in diameter, also laying tile and backfilling. According to the table the cost of these operations is 56 cents for each foot of depth one rod long. Since the trench is to be 6½ feet deep the total cost of one rod is obtained by multiplying the average cut by the cost per foot of depth, or 6½ times 56 cents or $3.64. Similarly the cost of labor for digging trench, laying tile and backfilling when the ditch is to be dug 5 feet deep and for 6 inch tile is found to be 5 times 22 cents or **$1.10** per rod.

*Data furnished by the American Society of Agricultural Engineers in 1919 and revised in 1922 by Q. C. Ayres, Associate Professor of Agricultural Engineering, Iowa State College.



Cat-tails, marsh grass, muskrats, mosquitoes, exchanged for profitable crop of corn—***by tile drainage***

The practical results of tile drainage are clearly demonstrated in the illustrations on this page. The upper illustration shows two fields of the University of Wisconsin Experimental Farm at Madison, Wis., in August, 1918. The field to the right is undrained and produces nothing but weeds and mosquitoes. The field to the left is tile drained and produces a big crop of corn. The illustrations below show the same fields in June, 1919

TILE DRAINAGE DID IT

Concrete drain tile are made in a wide range of sizes by up-to-date manufacturers

Size of Tile Required

A tile line is designed to carry a certain quantity of water in a given period of time. The volume of water which a tile line will carry is a product of the cross-sectional area of the tile and the rate of flow. It is common practice for engineers designing a drainage system to specify a size of tile which will carry off ¼ inch of water from the area to be drained in 24 hours. In sections where rainfall is extremely heavy or is of the nature of downpours, engineers often base their estimates on a run-off of ⅜ or even ½ inch in 24 hours. The table on page 15 indicates the number of acres that may be drained by tile ranging from 4 to 18 inches in diameter based on a ¼ inch run-off in 24 hours. For a ½ inch run-off just one-half as many acres will be drained by the tile specified and with a ⅜-inch co-efficient two-thirds as many acres.

Accurate lines and grades are needed, best furnished by competent engineers. Accuracy is economy

Factors which the engineer must take into account when estimating the size of tile are:

1. ***Area drained.*** (Other conditions being the same). The size of tile must in-

Outlet built into concrete head wall and protected by steel grating

crease with the increase in area to be drained. Tile lines spaced far apart require larger tile than when spaced closely.

2. ***The fall or slope.*** Water flows more rapidly where the slope is steep, consequently smaller tile will carry the same volume of water. Tile drains will operate on a fall as little as ½ inch in 100 feet, but large tile and very careful installation are then necessary. The table on this page indicates the effect of slope on the carrying capacity of different sized tile.

3. ***The texture of the soil.*** Water percolates through porous, sandy soil more readily than through dense clay, therefore larger tile are required to handle the water.

4. ***The amount and intensity of rainfall.*** Sections of the country having heavy rainfall require quick draining, therefore large tile. The rate at which the rain falls must also be considered.

AREA DRAINED BY TILE MAINS

(Based on Kutter's formula, n=.015)

Size of Tile	Fall Per 100 Feet							
	1¼in. or 0.1 ft.	2⅜in. or 0.2 ft.	3⅝in. or 0.3 ft.	4¾in. or 0.4 ft.	6in. or 0.5 ft.	9in. or 0.75 ft.	12in. or 1.0 ft.	24in. or 2.0 ft.
Inches	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
4	3	6	7	8	9	10	13	18
5	7	10	12	14	15	19	23	32
6	12	17	21	24	27	33	38	55
8	26	37	45	60	74	85	106	125
10	50	70	85	100	110	140	195	225
12	86	118	145	165	175	230	265	380
15	152	215	270	310	355	430	500	720
18	250	360	440	515	575	720	820	1150

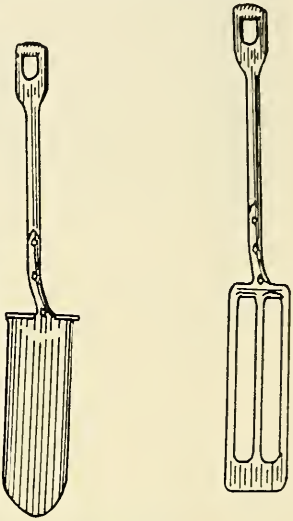
CONSTRUCTING TILE DRAINS

The Outlet

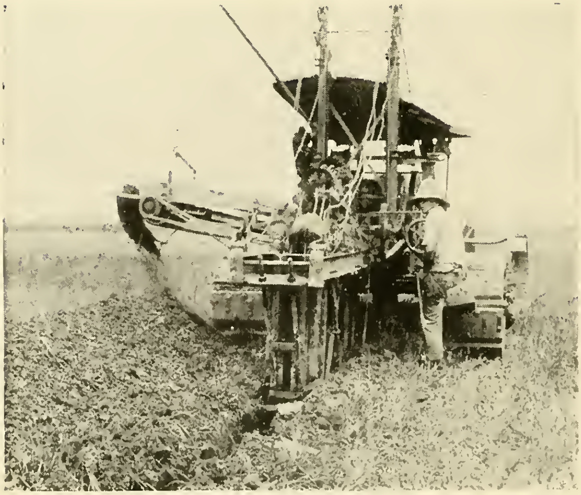
The outlet is a very important part of the drainage system. It should be located well above the stream in which it empties so that water will drain out at all times. A survey is often necessary to determine the best location. To protect the end of the tile a concrete head wall is generally used. It is easy to build, economical and permanent. In order to keep rabbits and other animals from crawling into the tile and clogging it, the outlet should be covered with wire mesh or grating.

Laying Out the Drain

The engineer usually makes a topographic survey of the area requiring drainage. From the data thus secured a map is drawn which indicates the character of the surface. The entire drainage system is then laid out on this map. When the tile lines are staked out in the field, this map is used. To indicate the location of the tile lines, small square stakes called hubs are driven flush with the ground along the proposed tile line at intervals of 50 or 100 feet. A longer stake is driven about three inches in front and a little to one side of each hub. It projects several feet above ground level and serves as a guide stake for the hub. On it the station number and the exact depth to dig below the hub are recorded.



Spades



Trench being dug by machine

Digging the Trench

The trench may be dug by hand or by machine. Digging should begin at the outlet and proceed upgrade. A narrow trench is preferable as it lessens the amount of soil which must be taken out and later filled in. Spades with long narrow blades have been perfected which make it possible to dig a very narrow trench.

Grading the Bottom of the Ditch

Great care should be exercised to excavate to proper grade so that there will be a uniform slope to the tile line with no low places. The bottom of the ditch should be dressed with a drain scoop to conform to the curvature of the tile. They will then lie uniformly bedded and with close fitting joints. The exact grade for the ditch bottom is conveniently established by measuring from a line drawn taut over the center or a little to one side of the ditch. An accompanying sketch suggests how this may be accomplished. At each hub a pair of stakes are driven, opposite each other, one on each side of the ditch and about 4 or 6 feet apart. To support the guide line, a lath or some light piece of lumber is nailed to the stakes at a definite height above the established grade for the bottom of the ditch, usually 6 feet, in which case a measuring gage 6 feet long is used to determine the exact depth to dig. The height to place the cross bar above the top of the hub may be found by subtracting the depth of the ditch, as indicated on the guide stake, from six.

Laying the Tile

Tile should be laid end to end so that the joints will be nearly closed to prevent entrance of sand or dirt. It is a mistake to think that the tile should be made porous so that water will seep through the tile wall. Even with the closest fitting joints enough water will enter the tile line in a comparatively short distance to tax it to its fullest capacity. The tile line should form a smooth continuous channel having a uniform slope. It will then conduct the greatest volume of water.

Blinding

As fast as tile are laid they are covered with about a foot of soil. Sometimes burlap is placed over the

Dressing the bottom of the ditch with a drain scoop

tile before the soil is added. Either of these will prevent silt from filtering into the tile and filling it up.

Filling the Trench

The trench may be filled by hand, by team and scraper, or by some appliance designed especially for the purpose. The ditch will usually have to be refilled after several heavy rains as the loose dirt will settle considerably. Refilling should not be neglected, otherwise water will use the ditch as a channel in times of flood and may wash out the tile or cut deep gullies.

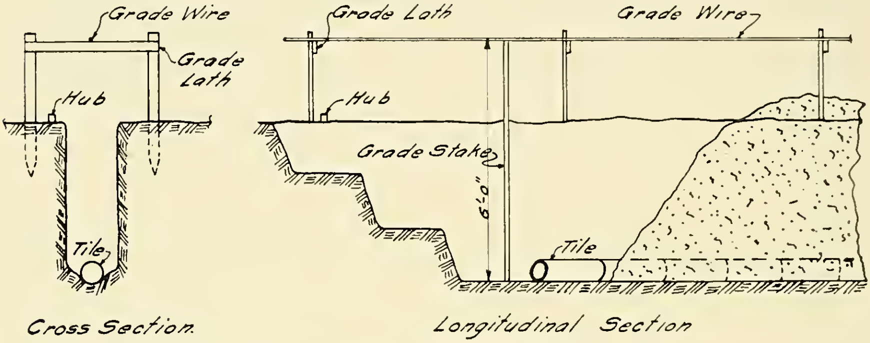


Diagram showing method of grading the bottom of the trench

SOME ESSENTIALS OF GOOD DRAIN TILE AND HOW CONCRETE MEETS THEM

Uniform Size

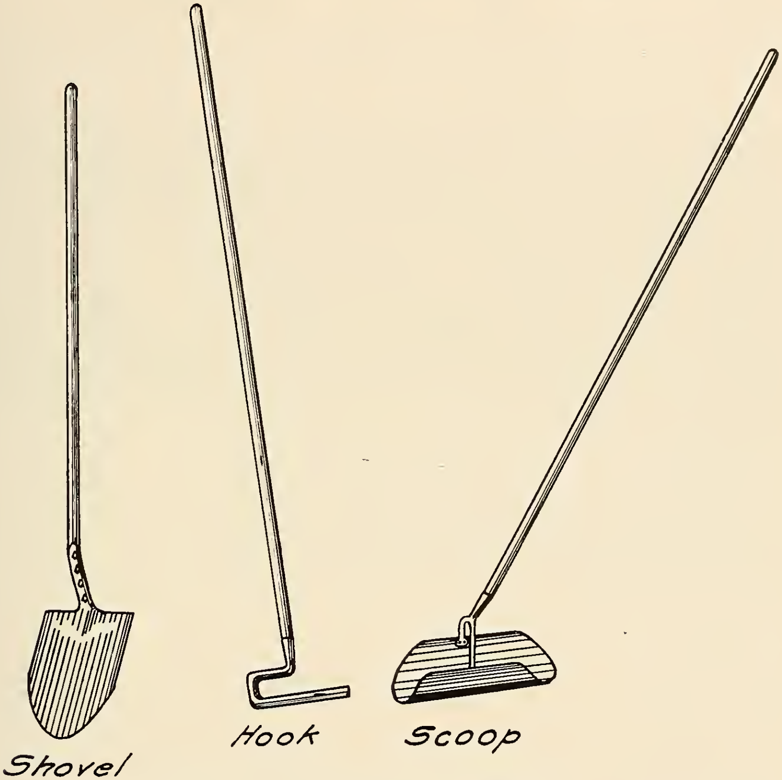
The volume of water which will flow through a tile line is limited to the capacity of the smallest tile, therefore all tile in a particular line should be the same size. To secure an uninterrupted flow of water, all tile should have the same diameter so there will be no offsets between adjacent tile. The diameter and length of concrete tile are accurately controlled by the machines in which the tile are molded. Twelve-inch length tile are twelve inches long.

Cylindrical in Form

Circular tile give greater capacity for their diameter than oval tile. A 4-inch circular tile may carry as much water as a 5-inch tile not a true circle. When all tile in a line are cylindrical they form a continuous cylindrical channel for the free and rapid movement of water. Concrete tile are always cylindrical.

Uniform in Strength

Tile should be uniform in strength as the failure of one tile in a line may put the whole system out of working order. Because concrete tile are of a uniform mixture and molded by machine and cured under uniform conditions, there is very little variation in strength. There are no soft ones.



Tools used in cleaning out trench and laying tile

Inside Surface

Rough places on the inside of tile are objectionable because they retard the flow of water. Concrete tile are molded by methods which produce a smooth interior finish.

Free From Cracks or Chips

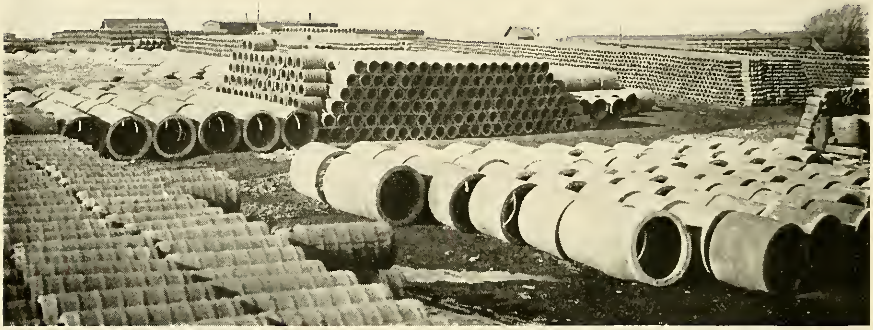
Cracks and chips decrease the strength of the tile and if large admit earth. Concrete tile are free from these defects.

Smooth, Regular and Parallel Ends

In order that tile may fit closely together it is desirable that the ends be smooth, regular and parallel, at right angles with the axis of the tile. No tile are superior to concrete tile in this respect.

WHERE TO BUY TILE

The farmer should not attempt to manufacture his own tile Experience and special equipment are necessary to turn out a high-grade product. Well-equipped concrete products plants should be patronized when concrete tile are needed. Their tile can be depended upon and is the most economical, everything considered.



Concrete tile are smooth and regular, free from cracks or chips and uniform in size and shape

SOME THINGS TO REMEMBER

Employ an engineer to plan and lay out your drainage system. The cost of his services may seem more than it would cost you to do some of the work which should really be left to him. Usually the mistakes due to inexperience cost more than what a competent engineer will charge to do the work properly.

Have your drainage system planned thoroughly. You may not be able to install a complete system all at once, but if it is all planned at one time you can install sections as time affords with the certainty that in the end the whole system will be complete, efficient and without overlapping.

Keep the records of your drainage system. From them it will be easy to plan necessary additions and the records will also be of considerable value if you decide to offer your farm for sale.

Strength of tile cannot be judged by mere inspection. Appearances in this respect are usually misleading. Have a sufficient number of tile promptly tested to assure yourself that they meet requirements.

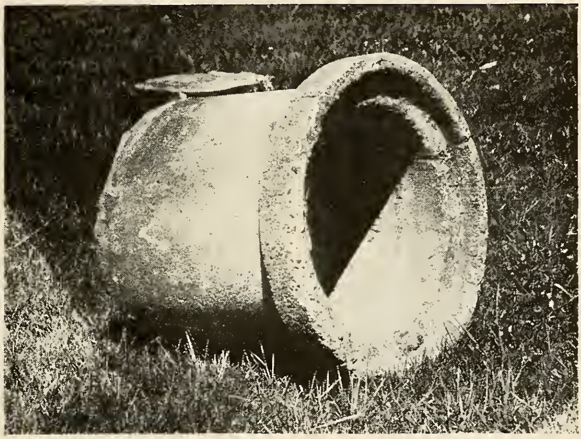
Poor tile or poor construction may cost less at first, but they will mean high maintenance and greater cost in the end. Good materials and good workmanship are cheaper.

If your drainage system does not come up to your expectations the first season, do not be discouraged. All soils, and especially the denser ones, drain more readily the second and third years than they do immediately after a drainage system is installed.

A drainage system should always be regarded as a permanent improvement and no tile should be used that will not endure. The permanent qualities of concrete tile are well known.

WHAT YOU CAN EXPECT WHEN YOU USE CONCRETE TILE

The following letters and illustrations show how concrete tile have been serving users for the past half century. They show how concrete tile can be relied upon to continue the service for which they were intended year after year. Some of the tile shown in the following illustrations were made more than fifty years ago by primitive methods and with inferior cement. You may judge by these letters what up-to-date concrete tile will do for you.



An example from Salem, Ill., of the permanence of concrete tile. This tile was made in 1854

Better Crops

"We dug up some tile that have been in peat soil for five years and find them in excellent condition with no signs of disintegration whatever. An outlet tile that was in for the same length of time was also in first-class condition, showing that freezing and thawing has no effect on it. Have had some lying in the yard that have gone through two winters of freezing and thawing without any bad effects.

"In regard to the advisability of tiling and results to be obtained, will say that this same land has been tiled five years, was very boggy and wet before tiling (not even making good pasture). We have now raised two crops of corn, one of oats and two of sugar beets. The corn was a good crop without manure either time, sugar beets averaged ten tons per acre with light dressing of manure and 150 pounds fertilizer per acre. Oats lodged and did not make a good yield.

"With the experience we have had, I regard tiling as a good investment."

Waukesha, Wis. *ALBERT PORTZ.*
March 16, 1921

Permanence

"In regard to the tile from my farm, size four inches in diameter, two feet in length and one-inch walls.

"These tile were made by J. C. Dexter Co., Cincinnati, Ohio, in the year of 1867 and placed in ditch by my father, David Shepherd, the same year, on farm six miles southeast of Hamilton, Ohio, now owned by myself. From that time until now these tile have been in perfect working order. The samples taken out and referred to in this description were removed in 1918 and replaced with tile from the J. C. Snider Plant at Camden, Ohio."

Hamilton, Ohio
June 25, 1921

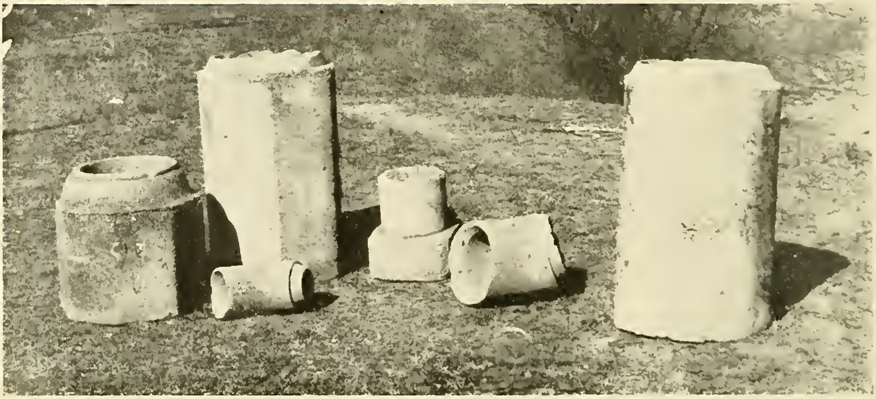
C. H. SHEPHERD.

Satisfaction

"I have used a great amount of cement tile in the last twelve years, something like 8000 feet, from five inches to ten inches. They have given the best of satisfaction and have been in ground seven years; never had to replace only one concrete tile, that was when the tiler made mistake in grade and ran tile within 18 inches of surface."

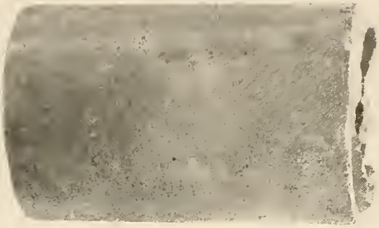
H. E. STEWART.

Elmore, Minn.
Aug. 22, 1921



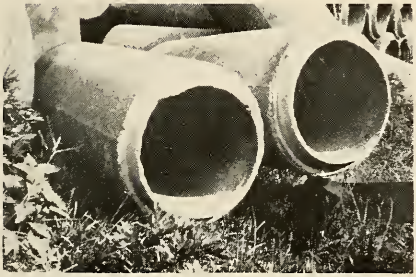
These pipe were taken from a trench near Logansport, Ind., after they had been in service for 50 years and were found to be in as good condition as when laid

Concrete pipe placed in the ground at Mishawaka, Ind., in 1889 and removed for examination after 20 years of service. The concrete was in perfect condition when the pipe was dug up.



This 18-inch pipe was placed in the ground in 1884 near Auburn, Ind., and removed in 1908. It was found to be in such excellent condition that it was relaid in another line.

This pipe was laid in a deep peat marsh near Lake Geneva, Wis., in 1890. It was dug up in 1921 and the concrete found to be in excellent condition. The specimen is now on exhibition in Madison, Wis.



Some 10-inch tile laid by L. H. Webster in South Bend, Ind., in 1886. They were dug up in 1905 when a larger sewer was laid and resold to be used again.

Concrete drain tile installed in a peat marsh in 1916, near Waupaca, Wis. Dug up and tested in 1921 they showed 60% greater strength than required by the specifications of the American Society for Testing Materials.

When You Build
Get This Service—Free

Durability, Fire-safety, Sanitation and Economy are qualities essential to satisfactory and profitable farm improvements. They are characteristic of well-built concrete structures. We place at your disposal **definite information on the use of concrete** so that these results will be assured.

Our District Offices listed below are service organizations in charge of experienced engineers. **Get their help in your building problems.** These district organizations are assisted by a staff of engineers at our headquarters in Chicago. In District Offices and at General Headquarters, we have engineers who specialize in the application of concrete to

Dairying
Stock Raising
General Farming
Fruit and Truck Growing
Home Building
Drainage, Water Supply and Sanitation
Floors and Pavements

These engineers are constantly in touch with the tests and experiments made by the various state and county farm bureaus, agricultural experiment stations and the U. S. Department of Agriculture. Their recommendations are based on the latest information obtainable on **how to decrease the labor and expense and increase the economy and profit in farming operations** with well-built farm improvements.

Educational booklets and pamphlets, fully illustrating and describing the important farm uses of concrete, await your request. Consult us freely.

PORTLAND CEMENT ASSOCIATION

A National Organization to Improve and Extend the Uses of Concrete

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Concrete for Permanence

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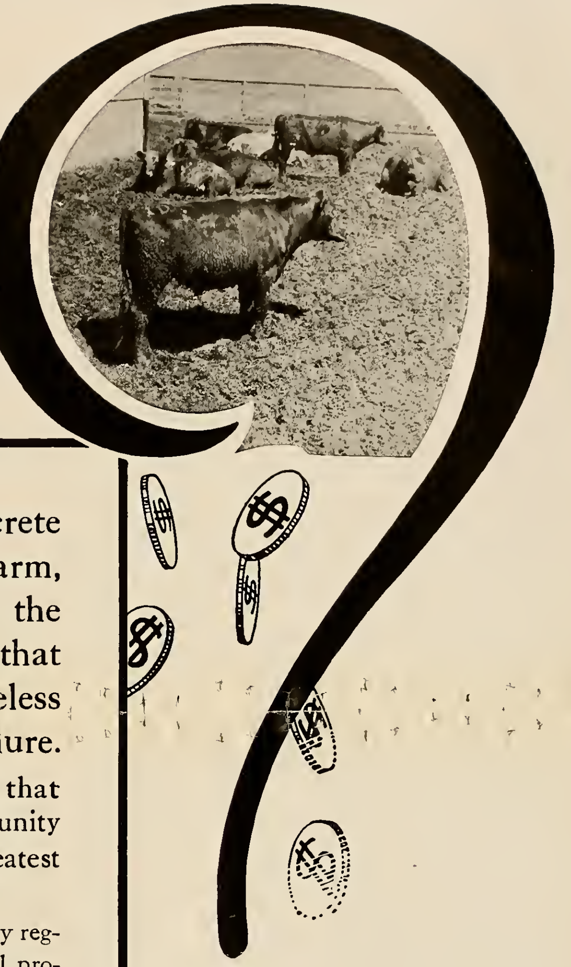
Is Your Manure Pile Leaking Dollars

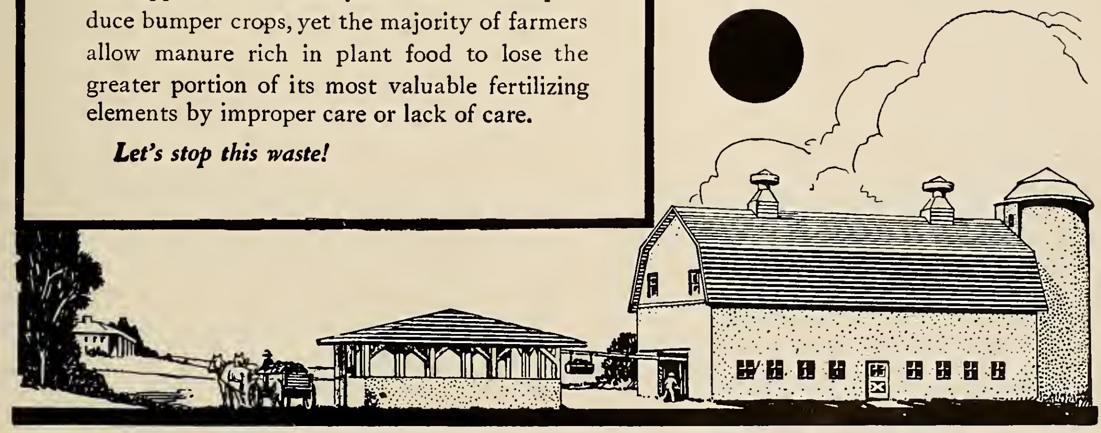


UNLESS you have a concrete manure pit on your farm, you are contributing to the millions of dollars of waste that results annually from careless handling of barnyard manure.

Good farm practice demands that we take advantage of every opportunity to make each acre give up its greatest possible yield.

Soil fertility built up and maintained by regular application of barnyard manure will produce bumper crops, yet the majority of farmers allow manure rich in plant food to lose the greater portion of its most valuable fertilizing elements by improper care or lack of care.

Let's stop this waste!



The Real Value of Manure

MANURE contains a large amount of plant food in the form of nitrogen, phosphorous and potash. This plant food has a definite money value based on its cost when purchased in the form of commercial fertilizer. Its value may also be determined by the increased crop yields resulting from its application to the soil. The following table taken from Pennsylvania Experiment Station Circular No. 67 shows the actual amount of manure collected in stables from various farm animals and the value of the plant food in the manure.

Figure Out the Value of the Manure Produced by Your Live Stock

	Tons in 1 Year	Value per Ton	Value for 1 Yr.
Horse	5.2	$6.09	$31.67
Dairy Cow	8.5	4.56	38.76
Other Cattle	4.0	5.47	21.88
Sheep	0.4	9.66	3.86
Hog	0.6	6.19	3.71

Results from several other experiment stations accord with the above figures and substantiate the fact that mixed manure is worth at least $5.00 per ton.

In addition to the plant food, manure furnishes soil organic matter which gives it extra value. Organic matter makes plant food already in the soil more available, supplies food for beneficial soil bacteria, prevents washing and blowing, and increases the water-holding capacity of the soil. In other words, organic matter means bigger crops.

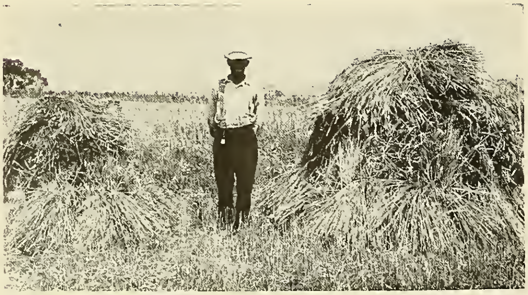
One-half the value of manure is in the liquid. The following data also taken from the Pennsylvania Agricultural Experiment Station Circular No. 67 show the comparative value of the solids and liquids in one ton of cow manure:

		Nitrogen	Phosphoric Acid	Potash	Total
Solid	Pounds	4	4	2.1	1558
	Value	$1.08	$0.24	$0.42	$1.74
Liquid	Pounds	6	0	6.0	442
	Value	$1.62		$1.20	$2.82

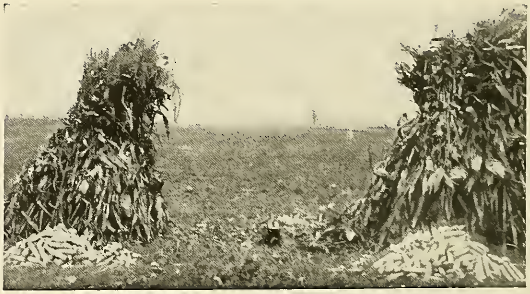
Total value $4.56

This table indicates that the liquid contains 61 per cent of the total value of cow manure. Similar experiments conducted by other stations demonstrate clearly that in mixed manure the liquids are at least equal in value to the solids. Every precaution should be taken to save the liquid part.

A ton of manure is worth exactly what it will produce in crop increases, minus the labor of handling. Below are the results of tests made by the Purdue Agricultural Experiment Station to determine the effect of manure in the production of wheat and corn. Manuring was at the rate of 10 tons per acre per rotation in a three year rotation of corn, wheat and clover. Manure was plowed under once in three years when preparing ground for corn.



Effect of manure on wheat, Purdue Agricultural Experiment Station.
Each shock is the produce from one-twentieth acre.
No Manure. Manured.
11 bu. wheat per acre. 30.7 bu. wheat per acre.



Effect of manure on corn, Purdue Agricultural Experiment Station.
Each shock is the produce from one-twentieth acre.
No Manure. Manured.
35.9 bu. corn per acre. 61.9 bu. corn per acre.

How Manure Is Wasted

As usually handled, loss of fertilizing elements in barnyard manure is great. The Indiana Agricultural Experiment Station estimates that one-third of all manure is wasted. According to its opinion, Indiana loses annually in this way more than $24,000,000. Tests conducted by other experiment stations indicate that the loss may be even greater than one-third. At the New Jersey Agricultural Experiment Station, five piles of manure exposed to the weather for 82 days lost 51 per cent of the nitrogen content, 51 per cent of the phosphoric acid and 61 per cent of the potash, or more than half of its fertilizing value. At the Cornell, New York, Station, horse manure exposed from April to September lost 62 per cent of its value. At the Maryland Station, 80 tons of manure in one year lost practically 66⅔ per cent of its value.

Loss of fertilizing elements in manure result from (a) Failure to save liquid content; (b) Fermentation (fire fanging); (c) Leaching (washing out of soluble plant food). Leaky or absorbent barn floors and unpaved feed lots for barnyards allow the greater portion of liquids to escape immediately. Pound for pound, the liquid content is worth more than the solids and the greatest single item of loss in the manure is from loss of liquid content.

In the process of decay, plant food in manure is changed into gas or soluble matter. Fermentation, or rotting, goes on most rapidly in loosely piled dry manure. Nitrogen escapes in the form of ammonia and the plant food elements — phosphorus and potash — are made soluble.

Soluble plant food is rapidly lost by leaching or washing by rains. An exposed manure pile only 25 feet square is drenched by 16 tons of water in 4 months, where the average rainfall is 31 inches per year. Many sections of the country have a greater rainfall than this, so it may readily be seen why plant food is soon washed out of manure exposed to the elements.

These losses can easily be prevented. Concrete floors and gutters in the barn, a paved barnyard and a concrete manure pit will make a combination that will prevent loss by leaching and will enable control of fermentation.

The New Jersey Extension Bulletin, Vol. I, No. 14, November, 1917, says:

> *"As an illustration of the loss which may take place in connection with the average dairy, we may estimate that 10 cows will produce 10 tons of manure per month, exclusive of bedding. Of this, 14,000 pounds will be the liquid manure, which will contain 60 pounds of nitrogen and 81 pounds of potash. If two-thirds of this liquid runs away there will be a loss of $12.00 worth of nitrogen, at 30 cents a pound, and $8.00 worth of potash, at 15 cents a pound, just half the price asked for potash at present, or a total loss of $20.00 a month.*
>
> *"The solid manure will contain 56 pounds of nitrogen, 28 pounds of phosphoric acid and only 14 pounds of potash. If this and the one-third of the liquid saved lie exposed for 4 or 6 months, further loss will amount to about half the nitrogen and potash and a third of the phosphoric acid, or an added loss of about $14.00. At the same time the bulk of the manure will shrink one-third. It is the soluble plant-food that is most readily leached out, so that remaining plant-food is probably worth only half the above valuations, or about $6.80—hardly enough to pay for carting and spreading."*

Loosely piled and exposed the fertilizing elements are soon burnt or washed out of this manure pile—a total loss.

A concrete manure pit like this conserves all the plant food so it can be returned to the field to produce bumper crops.

Begin Saving Ma

EVERY barn should have concrete floors. They are sanitary and easy to keep clean and make it possible to save the valuable liquid part of the manure. The value of a concrete floor was demonstrated in a recent test conducted at the Ohio Experiment Station, described in Extension Bulletin No. 8, 1918-19, which says:

> *"A plank floor under 30 cows was replaced by one of concrete, and the liquid which formerly had been allowed to escape through the cracks in the floor was drained into a cistern. Although these cows were ordinarily well bedded, the liquid manure that was gathered in this cistern in the course of four months contained 155 pounds of nitrogen and 222 pounds of potassium. If nitrogen is valued at 25 cents a pound and potassium 12 cents this liquid had a value of $65.39. On the basis of 7 months, which more nearly represents the time dairy cows are in the stable each year, the unabsorbed liquid would have a value of $114.43."*

Concrete Dairy Barn Floor Easy to Build

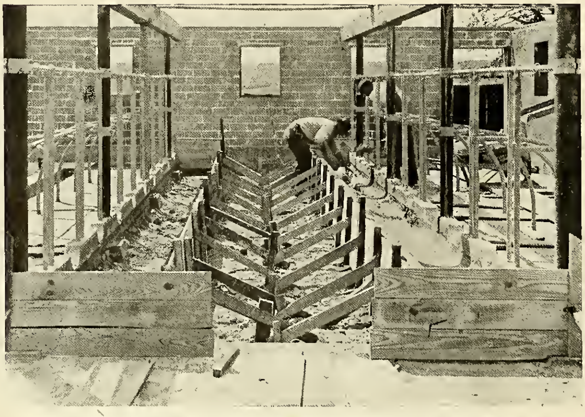
Before starting actual construction of a concrete floor, it is important to have a good floor plan layout to follow. If modern steel stall equipment is to be installed, a floor plan is necessary because changes in steel work to accommodate mistakes made in concrete work are costly. Most manufacturers of steel barn equipment furnish detailed plans for the convenience of their customers. If a concrete floor is to be laid in an old barn, the width of the feed and litter alleys depends, of course, on the space available. Length of stalls and width of mangers must be fixed to fit the kind of steel equipment to be installed. Length of stall platform, that is, distance from manger curb to gutter, will depend upon the breed of cows. The average is about 4 feet 8 inches but some breeds of cattle require 5 feet. Gutters should be about 16 inches wide so that a scoop shovel can easily be used to clean them. The stall side of the gutter should be from 6 to 9 inches deep and the walk side from 4 to 6 inches. Mangers are made in various shapes and sizes. The dimensions shown on the drawing accompanying have proved satisfactory. Most barn equipment manufacturers furnish forms to be used for shaping the concrete troughs, which must be used to secure a good job if their steel manger partitions are to be put in.

Preparatory to building a new barn floor, clean out all refuse on the area to be concreted, then grade the area to the required levels, allowing for the final thickness of the concrete. The soil should be compacted thoroughly by wetting down and tamping, if necessary, to aid in compacting. A fill of clean gravel, cinders or crushed stone is desirable, although not necessary if good drainage exists.

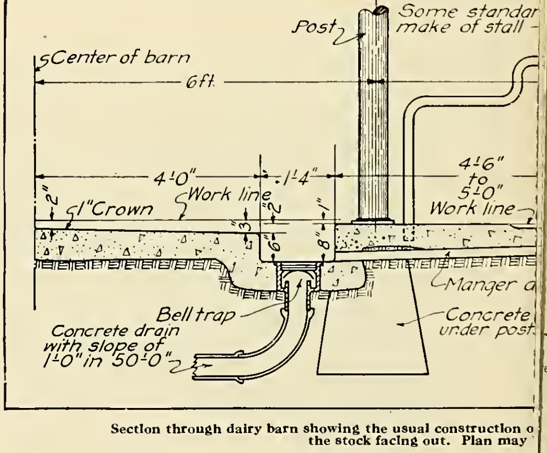
Forms should be firmly staked to line and level and should be of smooth lumber, free from defects that would prevent a neat looking job. They should not be removed until the concrete has hardened.

The stall curb is usually placed first. It should be not less than 4 inches thick and usually is about 6 inches high on the stall side. Some manufacturers provide anchors to be set in the curb form when the concrete is placed so that uprights of the stanchions can be conveniently attached later. The uprights supporting stanchions of certain kinds of equipment are embedded in the concrete so must be set to proper line and grade in the forms before concrete is placed. One manufacturer has perfected a clamp which bolts over the curb to hold stanchions.

Feed alleys and the side litter alleys are usually placed after the curb, and following this the stall platforms and



A watertight concrete dairy barn floor makes the saving of the valuable liquid part of manure easy. The gutter is connected by a drain with a concrete cistern like the one shown on the opposite page.



Section through dairy barn showing the usual construction o
the stock facing out. Plan may

nure in the Barn

mangers. Stall platforms should pitch about 1 inch from the curb to the gutter.

Mangers may be built with or after the stall platforms. By using a manger pattern, the trough can be easily and evenly finished. The surface of the manger should be finished smooth by light steel troweling. In the litter and feed alleys and stall floors, concrete should be finished with a wood float, which will leave an even but gritty surface providing good footing for the animals. Alleys should be pitched to the gutter, which should have a slope toward a suitable trapped drain leading to a concrete manure pit or cistern.

For all of this work a 1:2:3 mix and one-course construction is recommended, placing each section of floor complete from bottom to top of slab at one operation. By a 1:2:3 mix is meant concrete mixed in the proportion 1 sack of cement, 2 cubic feet of sand and 3 cubic feet of pebbles or crushed stone.

Some Principles to Observe in Making Good Concrete

For further information on proper methods of proportioning and mixing, write nearest office of the Portland Cement Association for booklet "Concrete Around the Home."

Use Only Suitable Materials

Success in the use of concrete follows the observance of a few simple directions. The sand should be clean and should range in size from fine particles to those that will just pass through a screen of ¼-inch mesh. Pebbles or crushed rock should be clean, hard and range in size from ¼-inch up. For dairy barn floors and cistern construction, the largest pebbles should not exceed 1½ inches. In the walls of the pit, pebbles up to 2½ inches may be used.

Mix in Accurate Proportions

For economy in cement and to make good concrete, the sand and coarse material must be measured separately and then mixed in the proportions specified. Most bank-run gravel contains too much sand and it should be screened and the sand and pebbles reproportioned.

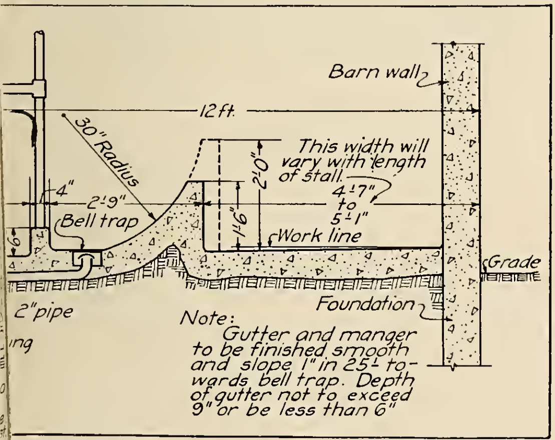
Use Clean Water

Clean water is essential. Water that is fit for drinking may be used. Enough water should be added to make a workable mixture of a quaky or jelly-like consistency. A sloppy mixture is to be avoided as excess water reduces the strength of concrete.

Protect Concrete While Hardening

Concrete requires moisture to develop its full strength and for that reason new concrete should be protected from the sun and wind so that it will not dry out or lose surface moisture. Finished work may be protected by a covering of canvas, straw or some similar material kept wet by frequent sprinkling.

"In the past, sanitation and ease of cleaning rather than consideration of profit have dictated the building of concrete floors. The great majority of people, however, will come to think of concrete floors as a necessary part of the average barn only when they realize that they actually are a profitable investment." *Ohio Extension Bulletin, Volume XIV, No. 8.*


Barn wall
12 ft.
30" Radius
This width will vary with length of stall.
2'-0"
4"
2'-9"
4'-7" to 5'-1"
1'-6"
Bell trap
Work line
6"
Grade
Foundation
2" pipe
ing
Note:
Gutter and manger to be finished smooth and slope 1" in 25' towards bell trap. Depth of gutter not to exceed 9" or be less than 6"

way manger, curb, stall, platform, gutter and litter alley with
rsed so that the cows will face in.

A concrete manure pit and cistern that have solved the problem of saving the manure.

Concrete Manure Pit Essential

FREQUENTLY farm work or other conditions makes it impossible to haul manure out on the fields daily, so a concrete pit is necessary to properly store manure until it can be drawn out and spread on the land. Watertight concrete floors and walls of a pit prevent loss of the valuable liquid contents and enable control of moisture and decomposition or rotting, that keep loss of fertilizing elements at a minimum.

A simple and inexpensive form of pit may be built in the form of a shallow concrete enclosure alongside of the barn, located so that it is easy to throw manure out of the barn windows into the pit and likewise, easy to load from the pit into the manure spreader. However, a more approved type of manure pit is shown in accompanying illustrations. Sanitation around the farm buildings is improved by having the pit some distance from the barn. Although not absolutely necessary, it is desirable to roof the pit, as excess water due to rainfall is thus prevented from accumulating in the pit.

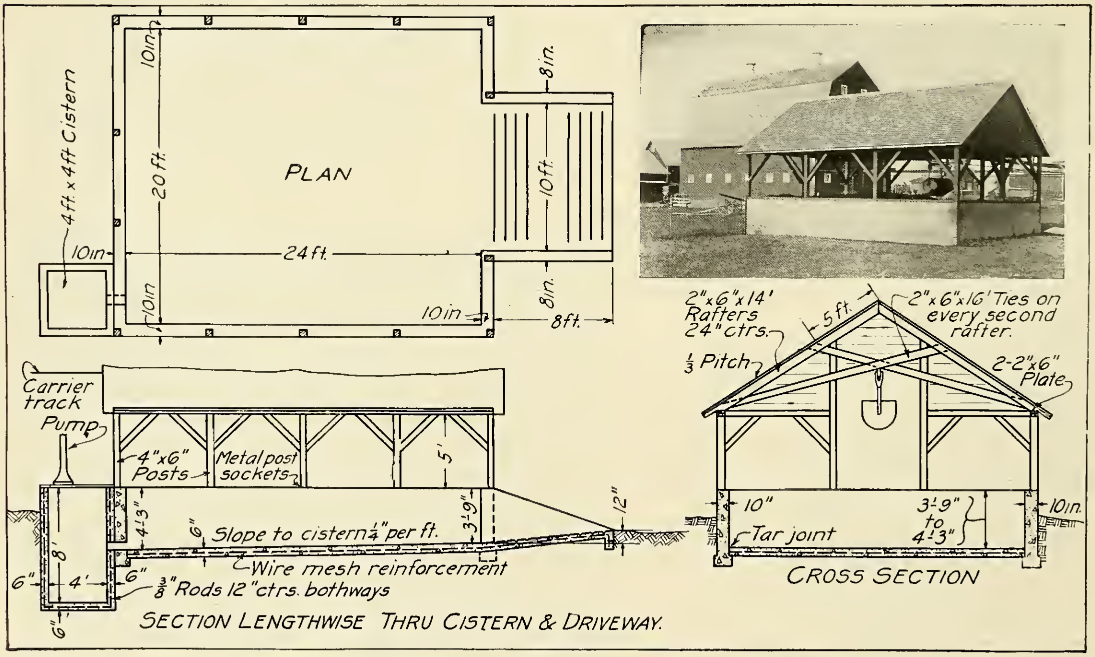
The location of the pit should be such that it will be handy for filling or emptying. A small pit may often be placed so that the spreader can be driven on either side, thus requiring no driveway. In the larger sizes, a driveway should be provided so that the spreader may be backed into the pit. For very long pits, it is a good plan to built a driveway entrance at each end so that the spreader may be driven entirely through the pit.

The following table gives the approximate dimensions of pit required for dairy herds of different sizes.

No. of Cows	Length	Width	Average Depth
10	16 feet	16 feet	4 feet
20	24 "	20 "	4 "
30	30 "	24 "	4 "
40	40 "	24 "	4 "

As it is usually not practical to use enough bedding in stalls to absorb all liquids, a cistern should be built near the pit to hold the unabsorbed portion. From this cistern the liquid may be pumped into a tank wagon for distribution or may be pumped over the manure in the pit to keep it moist. This replaces the moisture lost by evaporation. Cattle or hogs are frequently allowed access to the pit and they tramp the contents so compactly that there is little if any loss due to fermentation.

For the cistern and pit floor, use concrete mixed in the proportion 1 sack of portland cement to 2 cubic feet of sand and 3 cubic feet of pebbles. The proportion for the walls may be 1:2½:4. The walls of the pit should be built first. When the floor is placed, a ½-inch space should be left around the edge, which is later filled with tar to make a watertight joint. The amount and spacing of reinforcement is indicated on the plans.



Suggested design for a concrete manure pit and cistern having a capacity for 20 cows.

Paved and Covered Yards Good Investment

TO effect a complete saving of manure, the barnyard should be paved with concrete. A paved yard saves feed and labor as well as manure.

The covered yard or deep stall system, as its name indicates, is nothing more than an enclosed paved yard. The following paragraph from the New Jersey State Agricultural Extension Bulletin No. 14 gives a good description of a covered yard:

> "The easiest and most satisfactory method of holding large amounts of manure for several months with but little loss on the average farm is by the covered-yard system. This is a covered enclosed or sometimes an open shed under which the manure from the stable is thrown, and where it is scattered, mixed and compacted by the trampling of the stock and sometimes by the rooting of hogs. Young stock may be wintered conveniently in such a yard, and where sanitary regulations permit, milk cows also may spend almost all their time there except at milking and feeding time. Even the roughage may be fed from racks in the yard so that stable cleaning is reduced to a minimum. If sufficient straw or other litter is scattered in the yard at frequent intervals the stock keep quite as clean as when tied in stalls, and while somewhat more litter may be required, the animals have greater freedom and opportunity for exercise and their health is believed to be better. Large quantities of stalks or other litter can be worked in and decomposed better than in an open yard. The constant tramping and wetting with urine prevents nearly all destructive fermentation, and the manure comes out well rotted and in excellent condition."

An excellent example of a covered yard is shown in an accompanying illustration. Here the dairy cows enjoy the maximum amount of freedom and comfort. This place has plenty of sunlight which helps keep the interior pleasant and healthful. This yard is 100 feet long and 60 feet wide, and accommodates 60 cows. About 100 square feet of floor space is allowed per cow in a structure of this kind. The side walls are 10 feet high, which allows for an accumulation of manure 3 feet deep before hauling becomes necessary. This, of course, requires that there be a concrete wall at least 3 feet high around the enclosure. There is plenty of room for the spreader to drive around the feed racks located near the center of the yard so that the manure can be removed with the minimum amount of labor.

Concrete Floors Pay for Themselves in Eight Months

In a late test conducted at the Ohio Agricultural Experiment Station, the manure production of steers kept on concrete floors and well compacted earth floors was compared, with the following results: Analysis showed that the manure produced by a 1,000 pound steer in six months on a concrete floor had a value of $24.85, while on the earth floor the manure was worth only $20.34, a difference of $4.51 in favor of concrete. In eight months' time this saving was sufficient to pay the animal's share of the cost of a concrete floor. All further saving is clear profit, which amounts to $9.00 per 1,000 pound steer per year.

A covered shed where there is no waste of manure and where the dairy cattle enjoy the maximum amount of freedom and comfort.

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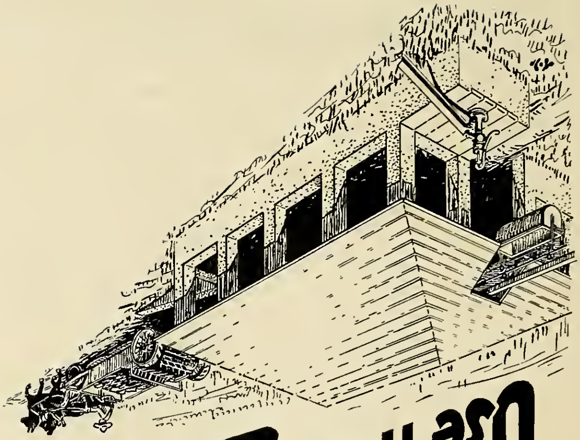

Don't Waste Manure - Use it for Bigger Crops.

"Concrete Around the Home"

This book of information gives complete instructions on how concrete should be made so as to obtain from it the best possible results.
Specific answers are given to questions relating to:

Proportions	**Mixing**	**Curing**
Consistency	**Placing**	**Form Work**

These questions are important to good concrete work and if handled in the manner recommended will be sure to lead to satisfactory results.

There are many permanent, economical improvements which the home owner can easily make of concrete during his spare time. The construction of a number of these, for instance: foundations, steps, walks, floors and pavements, troughs, tanks, cisterns and fence posts, are described in detail with drawings and photographs.

Other useful information contained in this book includes a table of recommended mixtures, how to figure the amount of cement and aggregates needed, and how to lay out a foundation. It is a book you will want to keep for future reference. Send for your free copy today.

PORTLAND CEMENT ASSOCIATION

A National Organization to Improve and Extend the Uses of Concrete

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F-8—25M—1-23-1

HOW TO BUILD

A Concrete Laying House for 100 Hens

WITHOUT REINFORCING STEEL

★ ★ ★

In planning structures that aid wartime farm production, you will find it helpful and desirable to use concrete for these reasons:

CONCRETE IMPOSES LEAST BURDEN ON WARTIME TRANSPORTATION, since sand and gravel are locally available nearly everywhere.

NEEDED WARTIME MATERIALS ARE CONSERVED—because of the shortage of steel due to the war this folder has been prepared to show how you can build a concrete poultry house without reinforcement.

FIRE AND STORM LOSSES ARE MINIMIZED—doubly desirable today when every destroyed building represents a loss of needed productive or storage capacity.

CONCRETE BUILDINGS MEET ALL REQUIREMENTS for highest farm efficiency. Moderate in first cost they offer sanitation, comfort to animals, lifetime service with low maintenance.

You can do concrete work yourself or ask your cement dealer for names of concrete contractors.

★ ★ ★

TO insure a healthy flock and high egg production, a poultry house must be warm, dry, well ventilated and ratproof. Concrete affords a practical means of meeting these requirements. Smooth concrete surfaces are easily cleaned and provide no crevices to harbor lice, mites or other poultry parasites. Concrete also keeps out rats, weasels and other unwelcome visitors.

Size to build. A 20x20-ft. house will provide sufficient space for 100 heavy hens or 150 light hens. Any required capacity can be obtained by adding 20x20-ft. units to either end of the building. The plan illustrated opposite consists of 2 units each 20x20 ft. making the building 20 ft. wide and 40 ft. long.

Building foundations and footings. The concrete foundation is made 8 in. thick on a footing 16 in. wide and 8 in. thick. Footings should extend down to firm soil. Use a mix of 1 part portland cement to 2¾ parts sand to 4 parts gravel or crushed rock up to 1½ in. in size. Use 5½ gal. water per sack of cement, using average damp sand.

Warm, dry concrete floors. Careful attention to the directions which follow will assure a warm, dry concrete floor. Cover the entire area to be floored with 6 to 8 in. of cinders or coarse gravel. This will bring the concrete

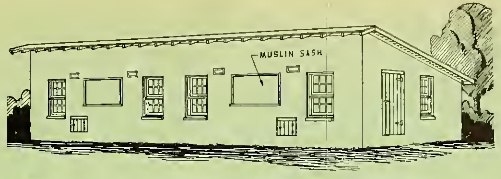

Fig. 1. General view of shed roof poultry house 40 ft. long. Two 20x20-ft. units are placed together.

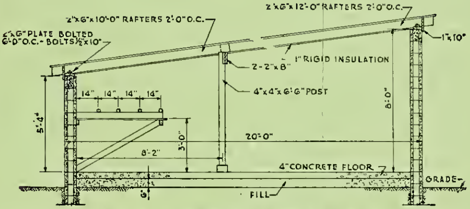

Fig. 2. Cross section of the shed roof house showing details of roosts and roof support.

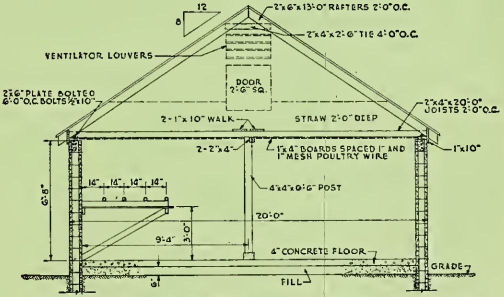
12
8
2"x6"x13'-0" RAFTERS 2'-0"O.C.
2"x4"x2'-6" TIE 4'-0"O.C.
VENTILATOR LOUVERS
DOOR 2'-6" SQ.
2"x6" PLATE BOLTED 6'-0"O.C. BOLTS ½"x10"
2"x4"x20'-0" JOISTS 2'-0"O.C.
2-1"x10" WALK
STRAW 2'-0" DEEP
2-2"x4"
1"x4" BOARDS SPACED 1" AND 1" MESH POULTRY WIRE
1"x10"
14" 14" 14" 14"
4"x4"x9'-6" POST
6'-8"
20'-0"
3'-0"
9'-4"
4" CONCRETE FLOOR
GRADE
FILL
6"

Fig. 3. Cross section of the straw loft gable roof poultry house, with details of construction.

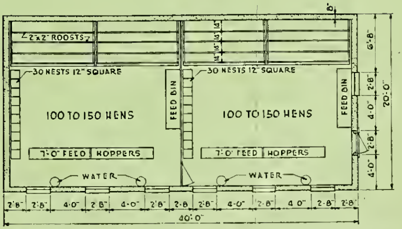

Fig. 4. Floor plan which may be used with either the shed or gable roof house. Use only 20-ft. length for 100 hens.

floor to 6 or 8 in. above the ground line. This fill is tamped firmly, after which a 1½-in. layer of concrete is placed and brought to an even surface with a straightedge. When this concrete hardens, usually in about 48 hours, lay smooth, heavy, waterproof asphalt roll roofing over the surface, lapping and carefully sealing the joints with roofing cement. Complete the floor by placing a 3-in. top course of concrete. For both courses of concrete use a mix of 1 part portland cement to 2¼ parts sand and 3 parts gravel or crushed stone up to ¾ in. in size. Use 5 gal. water per sack of cement, using average damp sand. Finishing is first done with a wood float after the surface has been leveled off with a strikeboard. Final finishing is done with a steel trowel.

Building walls. Walls are built of concrete masonry units 8 in. thick. Your local products manufacturer will gladly estimate the number of block needed and can put you in touch with a local mason. The mortar mix for concrete masonry walls is 1 part portland cement to 1 part lime putty or hydrated lime to 6 parts mortar sand. Sufficient water is added to make a workable mortar.

Type of roof. A gable roof straw loft laying house is widely recommended. However, some farmers prefer a shed roof. Rigid insulation 1 in. thick is nailed to the underside of rafters in the shed roof house while straw is used as insulation in the gable roof house.

Ventilation. Air intakes may be made as shown in Fig. 5. In the straw loft house, outlets consist of adjustable louvers in the gables. In the shed roof house the muslin-covered openings permit air circulation.

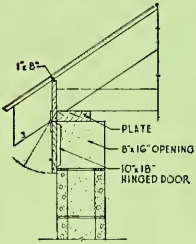

Fig. 5. Air intakes are made by omitting 1 block every 10 ft. in each wall and hinging a door in each opening which may be adjusted according to outside temperature.

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HOW TO BUILD A CONCRETE LAYING HOUSE FOR 100 HENS

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BULLETIN No. 12

The Progress and Logical Design of Reinforced Concrete

ASSOCIATION OF AMERICAN
PORTLAND CEMENT MANUFACTURERS
PHILADELPHIA, PA.

THE PROGRESS AND LOGICAL DESIGN OF REINFORCED CONCRETE

❧

By

ROSS F. TUCKER, M. AM. SOC. C. E.

President of the Tucker & Vinton Corporation

❧

READ BEFORE THE QUARTERLY MEETING
OF THE
ASSOCIATION OF AMERICAN PORTLAND
CEMENT MANUFACTURERS
HELD ON THE
STEEL PIER, ATLANTIC CITY, N. J., JUNE 12-13, 1906

THE PROGRESS AND LOGICAL DESIGN OF REINFORCED CONCRETE.

BY ROSS F. TUCKER, M. AM. SOC. C. E.

Those who are under the impression that the present popularity of reinforced concrete is largely a fad may be interested to note the progress of this type of construction since its inception in 1885, in terms of the production of Portland cement in the United States. In 1882 the output of Portland cement was 82,000 barrels. At this time, reinforced concrete was unknown, and the value of Portland cement concrete as a structural material was not dreamed of. Natural and Rosendale cements had the field practically to themselves and concrete, where it was used at all, was confined almost wholly to foundation and underground work. A glance at the accompanying illustration, Fig. 1, will show at once the enormous stride that the industry has made in a short quarter of a century. In Fig. 1 is shown the production of Portland cement in the United States at intervals of five years from 1880 to the present time. At the side is shown the development of the concrete industry in the same periods of time.

In 1885, Ernest L. Ransome, then of San Francisco, invented the twisted bar and demonstrated the principle underlying all reinforced structures whereby it is possible to incorporate steel bars in a mass of concrete in such a manner as to enable the concrete to withstand transverse loads. It will be noted by reference to the figure that at this time the production of Portland cement in the United States was 150,000 barrels. From 1885 to 1890, Ransome was engaged in applying his discoveries to works of the most elaborate and extensive character. When we take into consideration that, at that time, the subject of reinforced concrete was in a most elementary experimental stage, and that there were no accurate formulae or known valuations for determining concrete design, and that the appliances for making and handling concrete were of a primitive kind, we can appreciate

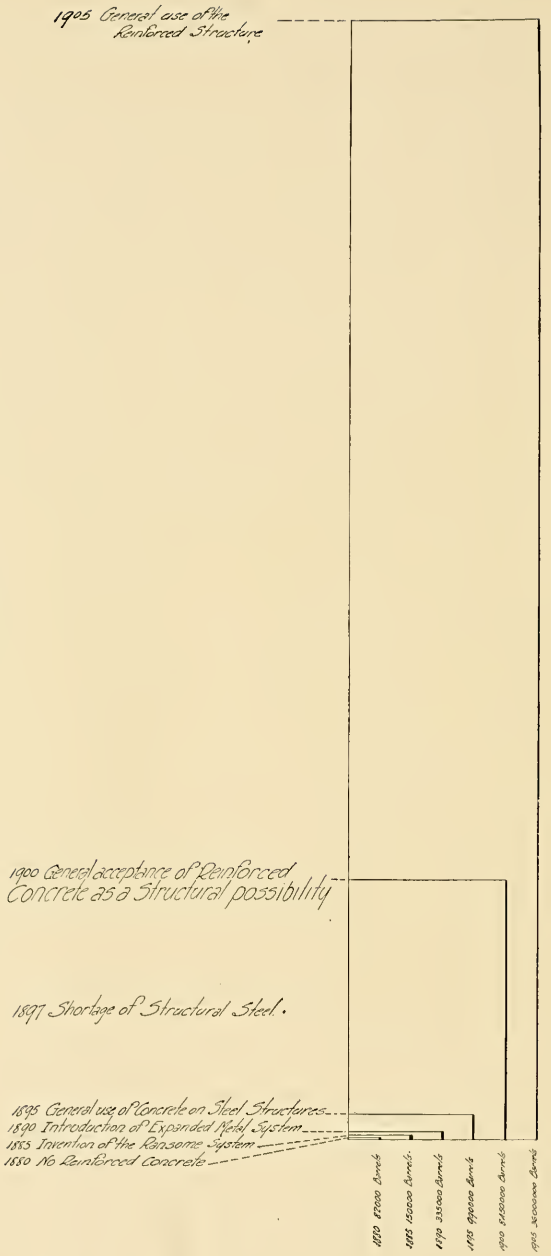

FIG. I.—SHOWING PROGRESS OF REINFORCED CONCRETE IN TERMS OF THE PRODUCTION OF PORTLAND CEMENT IN THE UNITED STATES

the difficulties with which he had to contend, and can bestow the greater credit and honor upon him for the courage and splendid mechanical and engineering ability which he displayed in undertaking the construction of steel concrete buildings of such magnitude in a country subject to earthquakes. Among the structures above referred to are the Museum Building (interior shown in Fig. 2), and Girls' Dormitory (Fig. 3), at Stanford University; the interior of Academy of Sciences (Fig. 4), the building for the Pacific Borax Company and the Tubbs Cordage Works, and the value of his discoveries has been further accentuated by the fact that during the recent great earthquake in California all of the above structures, comparatively crude as they were in design, came through the ordeal practically unscathed, where buildings of brick and stone in their immediate vicinity were entirely wrecked. In 1890 Ransome determined to intro-

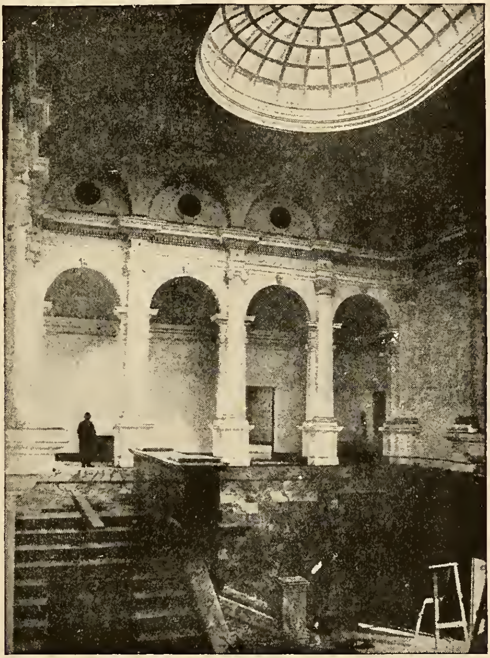

FIG. 2.—INTERIOR OF MUSEUM BUILDING,
STANFORD UNIVERSITY, 45′ SPANS
(Withstood earthquake perfectly)

duce his ideas throughout the country, and for a considerable time thereafter, the writer was engaged in lecturing before technical societies and architects and engineers generally on the subject of reinforced concrete and the possibilities of that type of structure. While these ideas were all of great interest to the technical public, they were so new to the building world at large that it was only here and there that they gained a foothold. The steel frame structure by this time had been brought to a high degree of development and architects and engineers, while interested in the possibilities of reinforced concrete, were loth to give up the steel skeleton and adopt a type of construction with which they were so entirely unfamiliar. The lesson, nevertheless, had its effect. About this time came the introduction of expanded metal and the mesh systems of concrete constructon, which enabled the architects to retain their steel structures and use concrete for the filling and arch work between beams in place of brick work and terra cotta. These methods enabled the architects to use concrete in a conservative manner and to become acquainted with its structural properties without abandoning the steel frame which constituted the main structural basis of their design. In this period, from 1890 to 1895, the production of Portland cement progressed from 300,000 barrels to 900,000 barrels, and the lessons learned from the use of concrete in this respect led to its adoption in a large number of projects originally planned for other material.

From this time on the use of concrete grew very fast. In 1897 and 1898 there came a great shortage in structural steel. Deliveries were so uncertain and remote that engineers the country over were at their wits' end to find ways and means for fulfilling their designs, and they turned at once to reinforced concrete to help them out of their dilemma. European systems of reinforced concrete were introduced and engineers generally began to study the subject from a scientific standpoint, with the result that by 1900 the steel concrete structure was recognized generally as a structural possibility and its adoption was considered for every conceivable kind of problem. At this period, the production of Portland cement in this country had reached 8,400,000 barrels per annum. In the succeeding five years, however, the popularity of concrete and the confidence of the building public in its properties were demonstrated in a most astonishing manner, for the production of Portland cement sprang from 8,400,000

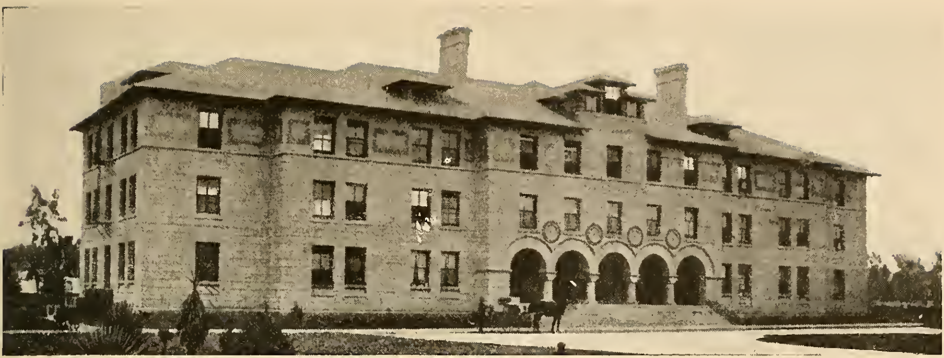

FIG. 3.—GIRLS' DORMITORY (ROBLE HALL), STANFORD UNIVERSITY

barrels in 1900 to 36,000,000 barrels in 1905.

Any one considering the progress of the industry, as noted, can hardly say that the reinforced structure is a fad, although it is to be admitted that concrete has been applied to many

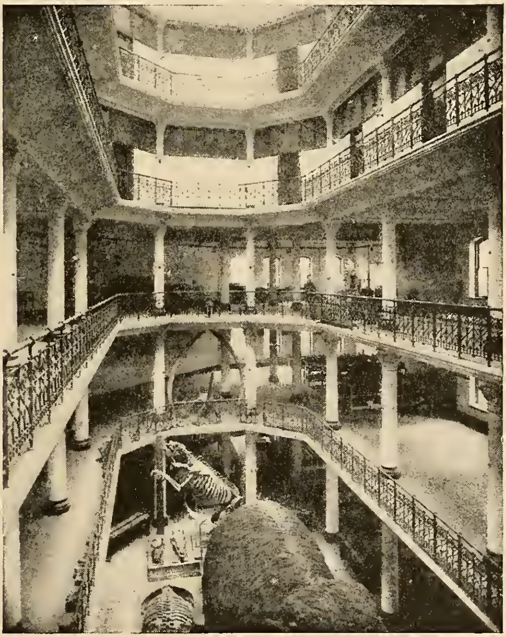

FIG. 4.—INTERIOR OF ACADEMY OF SCIENCES, SAN FRANCISCO
(Withstood fire and earthquake)

purposes for which it is not at all suitable. It is a fact now beyond dispute that the steel concrete structure has passed the experimental stage and has been adopted throughout the land as a building element of the greatest value. It is true, however, that much has yet to be done in the education of the architect and the engineer and in the use of concrete in a logical manner and for its real value. Owing to the comparative youth of this type of building, architects and engineers generally have not as yet given any great attention to the development of design essentially suitable to reinforced concrete. It is the general practice to design in brick, stone and steel and then to call upon a reinforced concrete engineer to reproduce a structure in reinforced concrete. This is an imperfect and unscientific method and unfair to the development of the true value of the concrete structure. The average architect and engineer is, as yet, too unfamiliar with the characteristics of concrete to design a structure solely from that point of view. He thinks in terms of brick and steel, designs in brick and steel and then attempts to adapt concrete to his structure. The architect who would design intelligently for reinforced concrete must think in terms of reinforced concrete, but up to the present time, the condition is similar to requiring a carpenter to think in the metric system when he has been all his life accustomed to figure in feet and inches. He must stop and translate and is unable to bring his mind to an adequate appreciation of his dimensions until he has so translated them. Reinforced concrete is a structural method possessing peculiar characteristics which are essentially its own, and any design which is to be carried out in this material should be adapted to their characteristics and qualifications. For instance, many have an idea that the cost of cement and the labor involved in the handling of concrete are the particular elements of cost in a concrete structure, whereas, as a matter of fact, the determining factor in the cost of concrete of whatever nature is the cost of the wood work and centering required for the carrying out of the design. The initial cost of a yard of concrete may be $5.00, but that same yard of concrete may be made to cost $40.00 by the addition thereto of elaborate forms necessary for the placing of the concrete in the position required in the design. On every structure projected for brick and steel, and afterwards converted into concrete, the cost of concrete

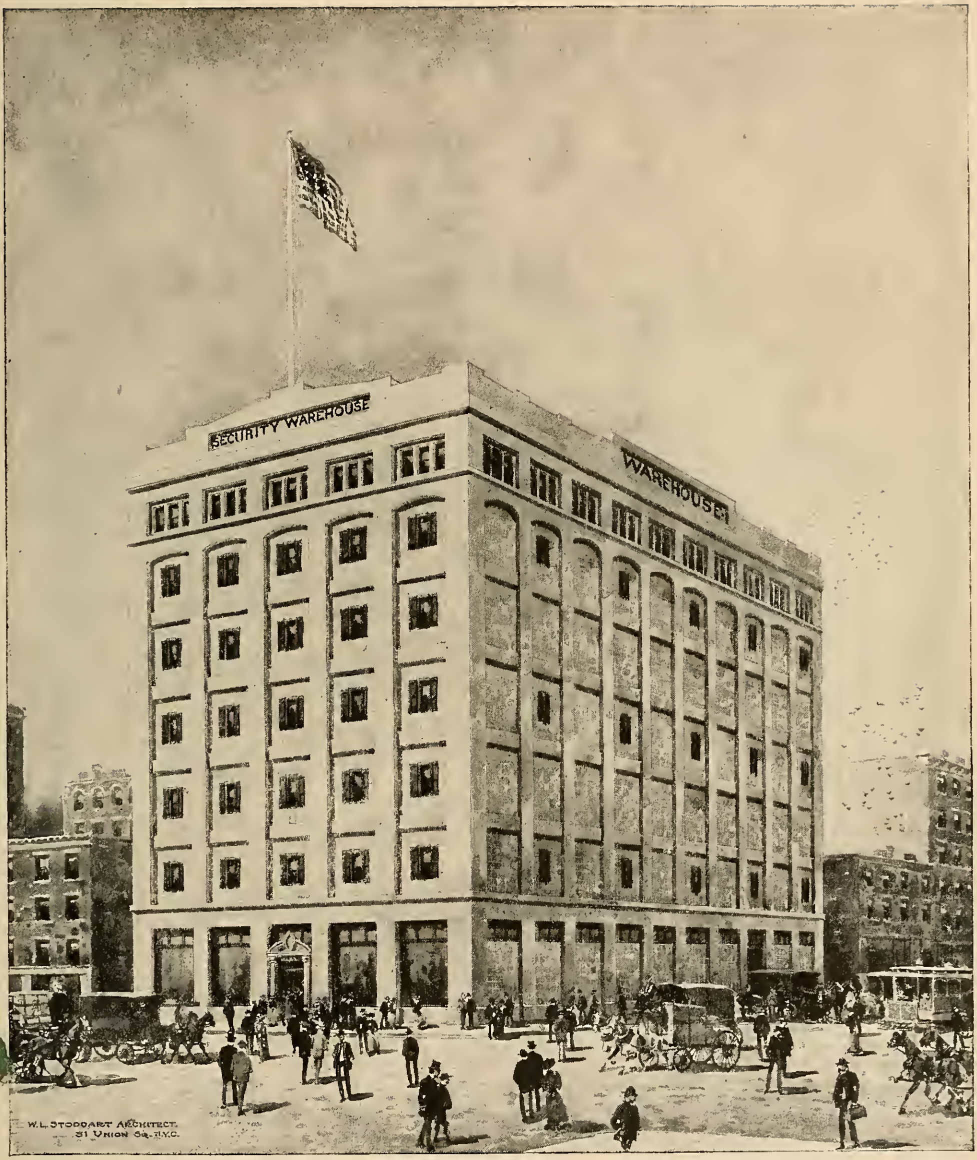
SECURITY WAREHOUSE
WAREHOUSE
W. L. STODDART ARCHITECT.
31 UNION SQ.-N.Y.C.

FIG. 5.—TYPICAL DESIGN OF STEEL CONCRETE WAREHOUSE

will vary for every yard from $5.00 to $40.00, depending upon the position in which it is placed and the elaboration of the forms necessary for the fulfilling of the design. It is, therefore, apparent that the greatest economy in the use of reinforced concrete is to be attained by keeping this fact in mind and designing the structure accordingly. The essence of economy in concrete work is the simplicity and duplication of forms, and this of itself demands the elimination of projecting members such as cornices, belt courses and offsets to the largest possible extent. The reinforced concrete building must be essentially a plain building and its architectural effect must be developed by the study of the relation of the openings to the masses, together with the assistance of such color scheme as may be applied by the insertion in the face of the structure of tile or mosaic work in color masses suitable to the problem.

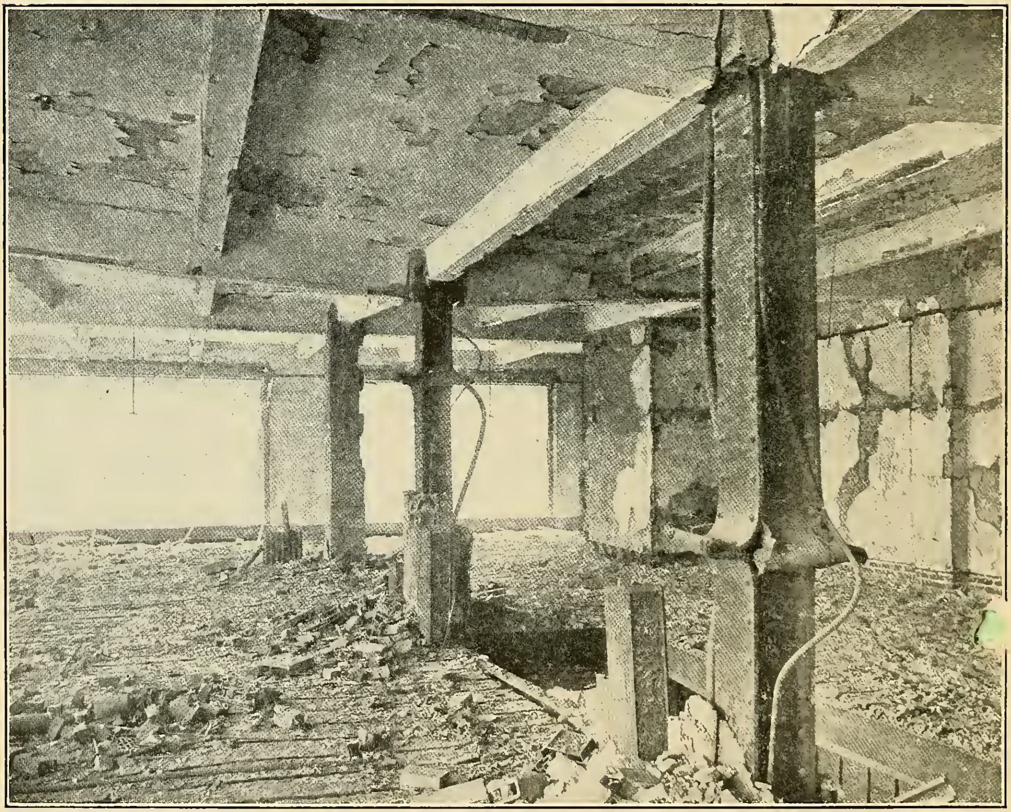

Fig. 6.—Interior of Bullock & Jones Building, San Francisco
(Showing condition of steel columns)

The above ideas are fairly well demonstrated in Fig. 5. It will be noted that the structure is of the skeleton type with the rectangle between the horizontal and vertical members filled in with block work or brick work, independent of the structure itself. Belt courses, cornices and offsets are eliminated in a very large degree and shadow effects are obtained from projections of a simple character. Window openings are small and are protected by fire shutters, thereby rendering the building practically proof against the ingress of fire from neighboring buildings. Experience has demonstrated that fire is not to be feared so much from within as from without, and the essential to good design of a fireproof character is that the building may be enclosed from top or bottom. As an indication of the danger to which the steel structure is subjected, through inadequate fireproofing, attention is called to Fig. 6, showing the condition of steel columns on the third floor of the Bullock & Jones Building in San Francisco. These columns were protected in an inadequate manner with terra cotta, but the sweep of the fire through the building destroyed the covering and exposed the steel work in such a way as to buckle the flange plates and subject the building to very great loss. It is absolutely certain that had these columns been covered with concrete of the same thickness, nothing of this sort would have happened.

Many of the monuments of Rome, that have endured for more than 2,000 years, were built of a concrete far inferior to that which we use to-day. So inferior, in fact, and so different in method and material as to be hardly entitled to the name of concrete, as we know it, at all. Still these monuments, stripped of their facings of mosaic, tile and stone by the ravages of time and conquest still endure. What, then, may we expect of the great structures which we are building under the eye of modern science? It is certain that the concrete of our day will endure far beyond the life of any natural stone and it is not too much to hope and predict that when our architects have become acquainted with the true characteristics of this wonderful material, they will create a new architecture more original and more truly American than any we have attained thus far. The future is replete with possibilities. We have learned thoroughly how to make concrete strong, let us learn now how to make concrete beautiful.

Bulletins relating to the use of Portland Cement, published by the Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia. Copies may be obtained upon application.

Bulletin No. 1. "Concrete Building Blocks."

Bulletin No. 2. "The Possibilities of Concrete Construction from the Standpoint of Utility and Art."

Bulletin No. 3. "Sand for Mortar and Concrete."

Bulletin No. 4. "Notes on Cement Testing."

Bulletin No. 5. Out of print.

Bulletin No. 6. Out of print.

Bulletin No. 7. "The Making and Driving of Corrugated Concrete Piles."

Bulletin No. 8. Out of print.

Bulletin No. 9. "Methods of Testing and Some Peculiarities of Cement."

Bulletin No. 10. "Decoration of Concrete with Colored Clays."

Bulletin No. 11. "Cost Reduction of Reinforced Concrete Work."

Bulletin No. 12. "The Progress and Logical Design of Reinforced Concrete."

Bulletin No. 13. "Forms for Concrete Construction."

Bulletin No. 14. Out of print.

Bulletin No. 15. "Concrete Bridges."

Bulletin No. 16. "Regulation and Control of Concrete Construction."

Bulletin No. 17. "Hydraulic Properties of Reground Cement Mortars."

Bulletin No. 18. "Reinforced Concrete Chimneys."

"Standard Methods of Testing and Specifications for Cement."

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"Results of Tests"—Made in our Laboratory during the World's Fair, St. Louis, Mo., 1904.

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STANDARD METHODS OF TESTING AND SPECIFICATIONS FOR CEMENT

CONTENTS

United States Government Specification for Portland Cement.

Standard Specifications for Cement of the American Society for Testing Materials.

Methods for Testing Cement—Report of the Committee of the American Society of Civil Engineers.

Chemical Analyses.

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UNITED STATES GOVERNMENT SPECIFICATION FOR PORTLAND CEMENT

CONTENTS

PAGE
EXECUTIVE ORDER 4
INTRODUCTORY STATEMENT 5

I. SPECIFICATION

1. Definition 6
2. Composition 6
3. Specific gravity 6
4. Fineness 6
5. Soundness 6
6. Time of setting 6
7–10. Tensile strength 7
11. Brand 7
12–13. Packages 7
14–15. Inspection 7

STANDARD METHODS OF TESTING

16–17. Sampling 8
18–19. Chemical analysis 8
20–21. Determination of specific gravity 9
22–23. Determination of fineness 9
24. Mixing cement pastes and mortars 10
25–28. Determination of normal consistency 10
29. Determination of soundness 11
30. Determination of time of setting 11
31. Tensile tests 11
32. Storage of test pieces 12
33–35. Standard sand 12

II. METHODS OF CHEMICAL ANALYSIS

Prefatory note 12

CHEMICAL ANALYSIS

Solution 13
Silica 13
Alumina and iron 14
Iron 14
Lime 15
Magnesia 15
Alkalies 16
Sulphuric anhydride acid 17
Total sulphur 17
Loss on ignition 18
Insoluble residue 18

III. INTERPRETATION OF RESULTS

CHEMICAL 18

PHYSICAL

Specific gravity 20
Fineness 21
Normal consistency 21
Mixing 23
Soundness 23
Time of setting 23
Tensile tests 24

IV. AUXILIARY SPECIFICATIONS

Bureau of Standards sieve specifications 25
Bureau of Standards specification for specific-gravity flasks 27
Standard form of briquettes 29

EXECUTIVE ORDER

It is hereby ordered that all Portland cement that may hereafter be purchased by any Department, Bureau, Office, or independent establishment of the Government, or that may be used in construction work connected with any of the aforesaid branches of the Government service, shall conform in every respect to the specification for Portland cement adopted by the Departmental Conference at the meeting held at the Bureau of Standards on February 13, 1912, and approved by the heads of the several departments (to be known as the United States Government Specification for Portland Cement): Provided, however, that such specification may be modified from time to time by any similar Departmental conference, with the approval of the heads of the several Departments.

WM. H. TAFT.

THE WHITE HOUSE,
April 30, 1912.

INTRODUCTORY STATEMENT

In June, 1911, the Secretary of the Department of Commerce and Labor arranged, through the Secretaries of the various departments, for a conference of Government engineers for the purpose of unifying the specifications for Portland cement used by the United States Government. At this conference a committee was appointed to consider existing specifications and to recommend a single specification for Portland cement to be used by all departments of the Government.

After an extended series of meetings of this committee, at which careful consideration was given to representative specifications for Portland cement, as well as to all available data on methods of tests, a tentative specification was developed, which was reported to the departmental conference at a general meeting held July 20, 1911.

In view of the desirability of agreement between the specifications in use by the public and those adopted by the Government, the committee was instructed by the conference to confer with representative consumers and manufacturers as well as the special committees of the national engineering societies more directly interested in the subject of cement specifications. As a result the tentative specifications first reported by the departmental committee were modified slightly, until substantial agreement was reached on practically all points except the methods of determining the normal consistency and time of setting, and the following specifications were unanimously adopted by the departmental conference at the meeting held February 13, 1912.

It was recognized that no specification can be considered final, but must be subject to revision from time to time as occasion requires, and provision will be made for such revision by the various Government departments, all of which have adopted the specification as recommended by the conference.

S. W. Stratton,
Director.

Approved:
Charles Nagel,
Secretary.

UNITED STATES GOVERNMENT SPECIFICATION FOR PORTLAND CEMENT*

I. SPECIFICATION

Definition.—1. The cement shall be the product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate mixture of properly proportioned argillaceous and calcareous substances, with only such additions subsequent to calcining as may be necessary to control certain properties. Such additions shall not exceed 3 per cent, by weight, of the calcined product.

Composition.—2. In the finished cement, the following limits shall not be exceeded:

	Per cent
Loss on ignition for 15 minutes	4
Insoluble residue	1
Sulphuric anhydride (SO_3)	1.75
Magnesia (MgO)	4

Specific Gravity.—3. The specific gravity of the cement shall be not less than 3.10. Should the cement as received fall below this requirement, a second test may be made upon a sample heated for 30 minutes at a very dull red heat.

Fineness.—4. Ninety-two per cent of the cement, by weight, shall pass through the No. 100 sieve, and 75 per cent shall pass through the No. 200 sieve.

Soundness.—5. Pats of neat cement prepared and treated as hereinafter prescribed shall remain firm and hard and show no sign of distortion, checking, cracking, or disintegrating. If the cement fails to meet the prescribed steaming test, the cement may be rejected or the steaming test repeated after seven or more days at the option of the engineer.

Time of Setting.—6. The cement shall not acquire its initial set in less than 45 minutes and must have acquired its final set within 10 hours.

---

*Circular No. 33, Bureau of Standards, May 1, 1912.

Tensile Strength.—7. Briquettes made of neat cement, after being kept in moist air for 24 hours and the rest of the time in water, shall develop tensile strength per square inch as follows:

	Pounds
After 7 days	500
After 28 days	600

8. Briquettes made up of 1 part cement and 3 parts standard Ottawa sand, by weight, shall develop tensile strength per square inch as follows:

	Pounds
After 7 days	200
After 28 days	275

9. The average of the tensile strengths developed at each age by the briquettes in any set made from one sample is to be considered the strength of the sample at that age, excluding any results that are manifestly faulty.

10. The average strength of the sand mortar briquettes at 28 days shall show an increase over the average strength at 7 days.

Brand.—11. Bids for furnishing cement or for doing work in which cement is to be used shall state the brand of cement proposed to be furnished and the mill at which made. The right is reserved to reject any cement which has not established itself as a high-grade Portland cement, and has not been made by the same mill for two years and given satisfaction in use for at least one year under climatic and other conditions at least equal in severity to those of the work proposed.

Packages.—12. The cement shall be delivered in sacks, barrels, or other suitable packages (to be specified by the engineer), and shall be dry and free from lumps. Each package shall be plainly labeled with the name of the brand and of the manufacturer.

13. A sack of cement shall contain 94 pounds net. A barrel shall contain 376 pounds net. Any package that is short weight or broken or that contains damaged cement may be rejected, or accepted as a fractional package, at the option of the engineer.

Inspection.—14. The cement shall be tested in accordance with the standard methods hereinafter prescribed. In general the cement will be inspected and tested after delivery, but partial or complete inspection at the mill may be called for in the specifications or contract. Tests may be made to determine the chemical composition, specific gravity, fineness, soundness, time of setting, and tensile strength, and a cement may be rejected in case it fails to meet any of the specified requirements. An agent of the contractor may be present at the making of the tests or they may be repeated in his presence.

15. In case of the failure of any of the tests, and if the contractor so desires, the engineer may, if he deem it to the interest of the United States, have any or all of the tests made or repeated by the Bureau of Standards, United States Department of Commerce and Labor, in the manner hereinafter specified, all expenses of such tests to be paid by the contractor. All such tests shall be made on samples furnished by the engineer.

Standard Methods of Testing

Sampling.—16. The selection of the samples for testing will be left to the engineer. The number of packages sampled and the quantity to be taken from each package will depend on the importance of the work, the number of tests to be made, and the facilities for making them.

17. The samples should be so taken as to represent fairly the material, and, where conditions permit, at least 1 barrel in every 50 should be sampled. Before tests are made samples shall be passed through a sieve having 20 meshes per linear inch to remove foreign material. Samples shall be tested separately for physical qualities, but for chemical analysis mixed samples may be used. Every sample should be tested for soundness, but the number of tests for other qualities will be left to the discretion of the engineer.

Chemical Analysis.—18. The method to be followed for the analysis of cement shall be that proposed by the Committee on Uniformity in the Analysis of Materials for the Portland Cement Industry, reported in the Journal of the Society for Chemical Industry, volume 21, page 12, 1902, and published in Engineering News, volume 50, page 60, 1903, and in the Engineering Record, volume 48, page 49, 1903.

19. The insoluble residue shall be determined on a 1-gram sample, which is digested on the steam bath in hydrochloric acid of approximately 1.035 specific gravity until the cement is dissolved. The residue is filtered, washed with hot water, and the filter-paper contents digested on the steam bath in a 5 per cent solution of sodium carbonate. The residue is then filtered, washed with hot water, then with hot hydrochloric acid, approximately of 1.035 specific gravity, and finally with hot water, then ignited and weighed. The quantity so obtained is the insoluble residue.

Determination of Specific Gravity.—20. The determination of specific gravity may be made with a standardized apparatus of Le Chatelier or other equally accurate form. Benzine (62° Baumé naphtha), or kerosene free from water should be used in making the determination. The cement should be allowed to pass slowly into the liquid of the volumenometer, taking care that the powder does not adhere to the sides of the graduated tube above the liquid and that the funnel through which it is introduced does not touch the liquid. The temperature of the liquid in the flask should not vary more than 1° F. during the operation. To this end the flask should be immersed in water. The results of repeated tests should agree with 0.01.

21. If the specific gravity of the cement as received is less than 3.10, a redetermination may be made as follows:

Seventy grams of the cement is placed in a nickel or platinum crucible about 2 inches in diameter and heated for 30 minutes at a temperature between 419 ° C. and 630 ° C. After the cement has cooled to atmospheric temperature the specific gravity shall be determined in the same manner as described above. The cement should be heated in a muffle or other suitable furnace, the temperature of which is to be maintained above the melting point of zinc (419 ° C.) but below the melting point of antimony (630 ° C.). This maximum temperature can be recognized as a very dull red which is just discernible in the dark.

Determination of Fineness.—22. The No. 100 and No. 200 sieves shall conform to the standard sieve specifications of the Bureau of Standards, Department of Commerce and Labor.

23. The determination of fineness should be made on a 50-gram sample, which may be dried at a temperature of 100 ° C. (212 ° F.) prior to sifting. The coarsely screened sample should be weighed and placed on the No. 200 sieve, which, with the pan and cover attached, should be held in one hand in a slightly inclined position and moved forward and backward in the plane of inclination, at the same time striking the side gently about 200 times per minute against the palm of the other hand on the upstroke. The operation is to be continued until not more than 0.05 gram will pass through in one minute. The residue should be weighed, then placed on the No. 100 sieve, and the operation repeated. The sieves should be thoroughly dry and clean. Determination of fineness may be made by washing the cement through the sieve or by a mechanical sifting device which has been previously standardized with the results obtained by hand sifting on equivalent samples. In case of the

failure of the cement to pass the fineness requirements by the washing method or the mechanical device, it shall be tested by hand.

Mixing Cement Pastes and Mortars.—24. The quantity of cement or cement and sand to be used in the paste or mortar should be expressed in grams and the quantity of water in cubic centimeters. The material should be weighed, placed upon a nonabsorbent surface, thoroughly mixed dry if sand be used, and a crater formed in the center, into which the proper percentage of clean water should be poured: the material on the outer edge should be turned into the crater by the aid of a trowel. As soon as the water has been absorbed the operation should be completed by vigorously mixing with the hands for one minute and a half. During the operation of mixing, the hands should be protected by rubber gloves. The temperature of the room and the mixing water should be maintained as nearly as practicable at 21 ° C. (70 ° F.).

Determination of Normal Consistency.—25. The normal consistency for neat paste to be used in making briquettes and pats should be determined by the ball method, as follows:

26. A quantity of cement paste should be mixed in the manner above described under Mixing Cement Pastes and Mortars, and quickly formed into a ball above 2 inches in diameter. The ball should then be dropped upon a hard, smooth, and flat surface from a height of 2 feet. The paste is of normal consistency when the ball does not crack and does not flatten more than one-half of its original diameter.

27. Trial pastes should be made with varying percentages of water until the correct consistency is obtained.

28. The percentage of water to be used in mixing mortars for sand briquettes is given by the formula:

$$y = \frac{2}{3}\frac{P}{n+1} + K$$

in which y is the percentage of water required for the sand mortar,
P is the percentage of water required for neat cement paste of normal consistency,
n is the number of parts of sand to one of cement by weight, and
K is a constant which for standard Ottawa sand has the value 6.5.

The percentage of water to be used for mortars containing 3 parts standard Ottawa sand, by weight, to 1 of cement is indicated in the following statement:

Percentage of water for neat cement paste	Percentage of water for 1 to 3 mortars of standard Ottawa sand
18	9.5
19	9.7
20	9.8
21	10.0
22	10.2
23	10.3
24	10.5
25	10.7
26	10.8
27	11.0
28	11.2
29	11.3

Determination of Soundness.—29. Pats of neat cement paste of normal consistency about 3 inches in diameter, one-half inch in thickness at the center, and tapering to a thin edge, should be kept in moist air for a period of 24 hours. One pat should then be kept in air and a second in water, at the ordinary temperature of the laboratory not to vary greatly from 21 ° C. (70 ° F.), and both observed at intervals for at least 28 days. A third pat should be exposed to steam at atmospheric pressure above boiling water for 5 hours.

Determination of Time of Setting.—30. The time of setting should be determined by the standardized Gillmore needles, as follows: A pat of neat cement paste about 3 inches in diameter and one-half inch in thickness with flat top, mixed at normal consistency, should be kept in moist air, at a temperature maintained as nearly as practicable at 21 ° C. (70 ° F.). The cement is considered to have acquired its initial set when the pat will bear, without appreciable indentation, a needle one-twelfth of an inch in diameter loaded to weigh one-fourth of a pound. The final set has been acquired when the pat will bear, without appreciable indentation, a needle one twenty-fourth of an inch in diameter, loaded to weigh 1 pound. In making the test the needle should be held in a vertical position and applied lightly to the surface of the pat. The pats made for the soundness test may be used to determine the time of setting.

Tensile Tests.—31. Tensile tests should be made on an approved machine. The test pieces shall be briquettes of the form recommended by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, and illustrated in Circular 33 of the Bureau of Standards. The briquettes shall be made of paste or mortar of normal consistency. Immediately after mixing, the paste or mortar should be placed in the molds, pressed in firmly by the fingers and smoothed off with a trowel without mechanical ramming. The material should be heaped above the mold, and in smoothing off, the trowel should be drawn over the mold in such a manner as to exert a moderate pressure on the material. The molds should be turned over and the operation of heaping and smoothing off repeated. Not less than three briquettes should be made and tested for each sample for each period of test. The neat tests are not considered so important as the sand tests. The briquettes should be broken as soon as they are removed from the water. The load should be applied at the rate of 600 pounds per minute.

Storage of Test Pieces.—32. During the first 24 hours after molding the test pieces should be kept in air sufficiently moist to prevent them from drying. After 24 hours in moist air the test pieces should be immersed in water. The air and water should be maintained as nearly as practicable at 21 ° C. (70° F.).

Standard Sand.—33. The sand to be used shall be natural sand from Ottawa, Ill., screened to pass a No. 20 sieve and retained on a No. 30 sieve.

34. Sand having passed the No. 20 sieve shall be considered standard when not more than 2 grams pass the No. 30 sieve after one minute continuous sifting of a 200-gram sample.

35. The No. 20 and No. 30 sieves shall conform to the standard sieve specifications of the Bureau of Standards, Department of Commerce and Labor.

II. METHODS OF CHEMICAL ANALYSIS

Prefatory Note.—While it may not be necessary to follow the standard method of analysis in routine tests when only a general indication of composition is desired, this method, including all precautions as stated in footnotes and italicized text, must always be followed when the results are to be used as the basis for rejection, or when an accurate knowledge of composition is desired.

The standard method can only yield accurate results in the hands of a careful and experienced analyst when all precautions are properly observed and even under these conditions the results obtained in the determinations of magnesia (MgO), sulphuric anhydride (SO_3), "loss on ignition" and "insoluble residue" may be ± 0.10 per cent in error, while in general results reported for magnesia tend to be too high. Under less favorable conditions the errors may be of much greater magnitude.

It is desired to emphasize these points so as to prevent rejection of material if the specified limits are exceeded by less than 0.10 per cent.

Chemical Analysis

METHOD SUGGESTED FOR THE ANALYSIS OF LIMESTONES, RAW MIXTURES, AND PORTLAND CEMENT BY THE COMMITTEE ON UNIFORMITY IN TECHNICAL ANALYSIS WITH THE ADVICE OF W. F. HILLEBRAND

Report of Subcommittee (New York Section Society of Chemical Industry) on Uniformity in Analysis of Material for the Portland Cement Industry[1]

(*All matter printed in italics, both in text and footnotes, has been added during the preparation of this circular at the suggestion and with the approval of W. F. Hillebrand, with special application to the analysis of Portland Cement.*)

Solution.—One-half gram[2] of the finely powdered substance is to be weighed out and, if a limestone or unburned mixture, strongly ignited in a covered platinum crucible over a strong blast for 15 minutes, or longer if the blast is not powerful enough to effect complete conversion to a cement in this time. It is then transferred to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, moistened with enough water to prevent lumping, and 5 to 10 c.c. of strong HCl added and digested with the aid of gentle heat and agitation until solution is completed. Solution may be aided by light pressure with the flattened end of a glass rod.[3] The solution is then evaporated to dryness, as far as this may be possible on the bath.

Silica (SiO_2).—The residue without further heating is treated at first with 5 to 10 c.c. of strong HCl, which is then diluted to half strength or less, or upon the residue may be poured at once a larger volume of acid of half strength. The dish is then covered and digestion allowed to go on for 10 minutes on the bath, after which the solution is filtered and the separated silica washed thoroughly with water. The filtrate is again evaporated to dryness, the residue without further heating taken up with acid and water, and the small amount of silica it contains separated on another filter paper. The papers containing the residue are transferred wet to a weighed platinum crucible, dried, ignited, first over a Bunsen burner until the carbon of the filter is completely consumed, and finally over the blast for 15 minutes and checked by a further blasting for 10 minutes or to constant weight.

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[1] The original method was reported in the Journal of the Society for Chemical Industry, vol. 21, p. 30, but the method was subsequently modified by the committee, and the above text practically conforms to that in the Engineering Record, vol. 48, p. 49; Engineering News, vol. 50, p. 60.

[2] *If a limestone, 0.75 gram should be used, the approximate equivalent of 0.5 gram of cement.*

[3] If anything remains undecomposed it should be separated, fused with a little Na_2CO_3, dissolved and added to the original solution. Of course a small amount of separated nongelatinous silica is not to be mistaken for undecomposed matter.

The silica, if great accuracy is desired, is treated in the crucible with about 10 c.c. of HF and 4 drops[4] H_2SO_4 and evaporated over a low flame to complete dryness. The small residue is finally blasted for a minute or two, cooled, and weighed. The difference between this weight and the weight previously obtained gives the amount of silica.[5]

Alumina and Iron (Al_2O_3 and Fe_2O_3).—The filtrate, about 250 c.c. from the second evaporation for SiO_2, is made alkaline with NH_4OH after adding HCl, if need be, to insure a total of 10 to 15 c.c. strong acid,[6] and boiled to expel excess of NH_3, or until there is but a faint odor of it, and the precipitated iron and aluminum hydroxides, after settling, are washed once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate is dissolved in hot dilute HCl, the solution passing into the beaker in which the precipitation was made. The aluminum and iron are then reprecipitated by NH_4OH_6, boiled, and the second precipitate collected and washed on the filter used in the first instance. The filter paper with the precipitate is then placed in a weighed platinum crucible (*the one containing the residue from the silica if this was corrected by hydrofluoric acid treatment*), the paper burned off, and the precipitate ignited and finally blasted 5 minutes, with care to prevent reduction, cooled and weighed as $Al_2O_3+Fe_2O_3$.[7]

Iron (Fe_2O_3).—The combined iron and aluminum oxides are fused in a platinum crucible at a very low temperature with about 3 to 4 grams of $KHSO_4$, or, better, $NaHSO_4$,[8] the melt taken up with so much dilute H_2SO_4 that there shall be no less than 5 grams absolute acid and enough water to effect solution on heating. The solution is then evaporated and eventually heated till acid fumes come off copiously. After cooling and redissolving in water the small amount of silica is filtered out, weighed and corrected by HF and H_2SO_4.[9] The filtrate is reduced by zinc, or preferably by hydrogen sulphide, boiling out the excess of the latter afterwards while passing CO_2 through the flask, and titrated with permanganate.[10]

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[4] *5 cc. HF and 2 drops H_2SO_4 are sufficient.*

[5] For ordinary control in the plant laboratory this correction may, perhaps, be neglected; the double evaporation never. *The silica so found does not represent quite all in the material under analysis; a little has passed into the filtrate. Account should be taken of a possible loss in weight of the crucible itself, if the blast is very powerful.*

[6] *And 2 or 3 c.c. of bromine water. Bromine water is used for the purpose of collecting practically all the manganese here, instead of allowing it to distribute among several different precipitates.*

[7] This precipitate contains TiO_2, P_2O_5, Mn_3O_4.

[8] *Or the corresponding pyrosulphates which are less troublesome and more effective than the acid sulphates.*

The strength of the permanganate solution should not be greater than 0.0040 g Fe_2O_3 per c.c.

Lime (CaO).—To the combined filtrate from the $Al_2O_3+Fe_2O_3$ precipitate a few drops of NH_4OH are added, and the solution brought to boiling. To the boiling solution 20 c.c. of a saturated solution of ammonium oxalate is added, and the boiling continued until the precipitated CaC_2O_4 assumes a well-defined granular form. It is then allowed to stand for 20 minutes, or until the precipitate has settled, and then filtered and washed. The precipitate and filter are placed wet in a platinum crucible, and the paper is burned off over a small flame of a Bunsen burner. It is then ignited, redissolved in HCl, and the solution is made up to 100 c.c. with water. Ammonia is added in slight excess, and the liquid is boiled. If a small amount of Al_2O_3 separates this is filtered out, weighed, and the amount added to that found in the first determination, when greater accuracy is desired. The lime is then reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed,[11] weighed as oxide after ignition and blasted in a covered crucible to constant weight, or determined with dilute standard permanganate.[12]

Magnesia (MgO).—The combined filtrates from the calcium precipitates are acidified with HCl and concentrated on the steam bath to about 150 c.c., 10 c.c. of saturated solution of $Na(NH_4)HPO_4$ is added, and the solution boiled for several minutes. It is then removed from the flame and cooled by placing the beaker in ice water. After cooling, NH_4OH is added, drop by drop, with constant stirring until the crystalline ammonium-magnesium orthophosphate begins to form, and then in moderate excess, the stirring being continued for several minutes. It is then set aside for several hours in a cool atmosphere and filtered. The precipitate is redissolved in hot dilute HCl, the solution made up to about 100 c.c., 1 c.c. of a saturated solution of $Na(NH_4)HPO_4$ added, and ammonia, drop by drop, with constant stirring until the precipitate is again formed as described and the ammonia is in moderate excess. It is then allowed to stand for about 2 hours,[13] when it is filtered on a paper or a Gooch crucible, ignited, cooled, and weighed as $Mg_2P_2O_7$.

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[9] This correction of Al_2O_3, Fe_2O_3 for silica should not be made when the HF correction of the main silica has been omitted, unless that silica was obtained by only one evaporation and filtration. After two evaporations and filtrations 1 to 2 mg. of SiO_2 are still to be found with the Al_2O_3, Fe_2O_3.

[10] In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

[11] The volume of wash water should not be too large; vide Hillebrand, *United States Geological Survey, Bull. 422, p. 110.*

[12] The accuracy of this method admits of criticism, but its convenience and rapidity demand its insertion.

The pyrophosphate invariably contains calcium which can be determined as follows:

Dissolve the ignited pyrophosphate in a little dilute H_2SO_4 *and add enough absolute alcohol to make about 90 to 95 per cent of the final volume. After several hours collect the small and sometimes almost invisible precipitate of calcium sulphate on a small filter and wash it free of phosphoric acid with alcohol. Dry the filter and extract from it the precipitate by a few cubic centimeters of hot water acidulated with HCl. Make this solution alkaline with ammonia, throw in a few crystals of ammonium oxalate and continue heating till a precipitate becomes visible. After an hour filter, wash and ignite to calcium oxide. Its weight, averaging perhaps 0.5 mg., is to be added to that of the lime already found and subtracted as tricalcium phosphate (not pyrophosphate) from that of the magnesium pyrophosphate.*

In order to determine approximately the iron and aluminum present the following procedure may be followed:

Evaporate the alcoholic filtrate from the calcium sulphate and heat the residue to destroy separated organic matter. Take the residue up with a little CHl and water and when dissolved add a drop of bromine water. Add ammonia till the magnesia is again precipitated and let stand for an hour. Decant most of the supernatant liquid and add slowly, drop by drop, acetic acid till all fine-grained matter has dissolved. Usually there will remain a little flocculent matter which is likely to consist in greater part or wholly of phosphates of iron and aluminum (and manganese if this last was not removed by bromine and ammonia as in the section on Alumina and Iron Oxides). After ignition the precipitate often shows a reddish color. Unless great care is exercised this separation will lead to erroneous results, either by inclusion of magnesium with the impurities as weighed or by loss of these in consequence of using too much acetic acid.

Alkalies (K_2O and Na_2O).—For the determination of the alkalies, the well-known method of Prof. J. Lawrence Smith is to be followed, either with or without the addition of $CaCO_3$ with NH_4CL.

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[13] *A paper filter should always be used if the pyrophosphate is to be corrected for contaminations.*

Sulphuric Anhydride Acid (SO_3).—One gram of the substance is dissolved in 15 c.c. (*5 c.c.*) of HCl, *and 45 c.c. water*, filtered, and the residue washed thoroughly.[14]

The solution is made up to 250 c.c. in a beaker and boiled. To the boiling solution 10 c.c. of a saturated solution of $BaCl_2$[15] is added slowly, drop by drop, from a pipette and the boiling continued until the precipitate is well formed, or digestion on the steam bath may be substituted for the boiling. It is then set aside overnight, or for a few hours, filtered, ignited, and weighed as $BaSO_4$.

Total Sulphur.—One gram of the material is weighed out in a large platinum crucible and fused with Na_2CO_3 and a little KNO_3, being careful to avoid contamination from sulphur in the gases from source of heat. This may be done by fitting the crucible in a hole in an asbestos board.

The melt is treated in the crucible with boiling water and the liquid poured into a tall narrow beaker and more hot water added until the mass is disintegrated. The solution is then filtered. The filtrate contained in a No. 4 beaker is to be acidulated with HCl and made up to 250 c.c. with distilled water, boiled, the sulphur precipitated as $BaSO_4$ and allowed to stand overnight, or for a few hours.

The following procedure is in accordance with the recommendation of W. F. Hillebrand in United States Geological Survey, Bulletin 422, page 227:

In a platinum crucible mix 1 gram of the sample with one-half gram of sulphur-free sodium carbonate. Place the covered crucible in a hole in an asbestos board that is held in a somewhat inclined position and apply a blast flame upon the crucible below the asbestos for 10 to 15 minutes. Transfer the sintered mass to a beaker and cover with water. Cleanse the crucible with dilute hydrochloric acid and pour the solution into the beaker. Add more acid till decomposition is complete in the cold or on gently warming. Filter, wash with hot water, dilute to 150 to 200 c.c., boil, and precipitate with barium chloride.

It should be borne in mind that by neither of the methods given is a barium sulphate obtained that is perfectly pure. Ferric (and if present alkali) sulphate, also barium chloride, contaminate it and it is im-

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[14] Evaporation to dryness is unnecessary unless gelatinous silica should have separated, and should never be performed on a bath heated by gas; vide Hillebrand; *United States Geological Survey, Bulletin 422, p. 198.*

[15] *Ten per cent. solution is preferable to one that is saturated.*

possible to correct for them directly. The most convenient way to obtain a correction is by a blank with a solution containing sulphur and the other main constituents of the cement in approximately the amounts and proportions found in the test sample.

Loss on Ignition.—Half a gram of cement is to be weighed out in a (*covered*) platinum crucible, placed in a hole in an asbestos board so that about three-fifths of the crucible projects below, and blasted 15 minutes, preferably with an inclined flame. The loss by weight, which is checked by a second blasting of 5 minutes, is the loss on ignition.

Recent investigations have shown that large errors in results are often due to the use of impure distilled water and reagents. The analyst should, therefore, test his distilled water by evaporation and his reagents by appropriate tests before proceeding with his work.

Insoluble Residue.—*The insoluble residue*[16] *shall be determined on a 1-gram sample which is digested on the steam bath in hydrochloric acid of approximately 1.035 specific gravity until the cement is dissolved. The residue is filtered, washed with hot water, and the filter paper contents digested on the steam bath in a 5 per cent solution of sodium carbonate. The residue is then filtered, washed with hot water, then with hot hydrochloric acid, approximately of 1.035 specific gravity, and finally with hot water, then ignited and weighed. The quantity so obtained is the insoluble residue.*

III. INTERPRETATION OF RESULTS

Chemical

The composition of normal Portland cement has been the subject of a great deal of investigation and it can be said that the quantities of silica, alumina, oxide of iron, lime, magnesia, and sulphuric anhydride can vary within fairly wide limits without materially affecting the quality of the material.

A normal American Portland cement which meets the standard specifications for soundness, setting time and tensile strength has an approximate composition within the following limits:

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[16] This determination was not considered by the Committee of the Society of Chemical Industry and is reproduced from paragraph 19 of the United States Government specification for Portland cement.

	Per Cent
Silica	19–25
Alumina	5–9
Iron oxide	2–4
Lime	60–64
Magnesia	1–4
Sulphur trioxide	1–1.75
Loss on ignition	0.5–3.00
Insoluble residue	0.1–1.00

It is also true that a number of cements have been made both here and abroad which have passed all standard physical tests in which these limits have been exceeded in one or more particulars, and it is equally true that a sound and satisfactory cement does not necessarily result from the above composition.

It is probable that further investigation will give a clearer understanding of the constitution of Portland cement, but at present chemical analysis furnishes but little indication of the quality of the material.

Defective cement usually results from imperfect manufacture, not from faulty composition. Cement made from very finely ground material, thorughly mixed and properly burned, may be perfectly sound when containing more than the usual quantity of lime, while a cement low in lime may be entirely unsound due to careless manufacture.

The analysis of a cement will show the uniformity in composition of the product from individual mills, but will furnish little or no indication of the quality of the material. Occasional analysis should, however, be made for record and to determine the quantity of sulphuric anhydride and magnesia present.

The ground clinker as it comes from the mill is usually quick setting which requires correction. This is usually accomplished by the addition of a small quantity of more or less hydrated calcium sulphate, either gypsum or plaster of Paris. Experience and practice have shown that an addition of 3 per cent or less is sufficient for the purpose.

Three per cent of calcium sulphate ($CaSO_4$) contains about 1.75 per cent sulphuric anhydride (SO_3), and as this has been considered the maximum quantity necessary to control time of set, the specification limits the SO_3 content to 1.75 per cent.

The specification prohibits the addition of any material subsequent to calcination except the 3 per cent of calcium sulphate permitted to regulate time of set. Other additions may be difficult or impossible to detect even by a careful mill inspection during the process of manufacture, but as the normal adulterant would be ground raw material, an excess of "insoluble residue" would reveal the addition of silicious material, and an excess in "loss on ignition" would point to the addition of calcareous material when either is added in sufficient quantity to make the adulteration profitable.

The effect of relatively small quantities of magnesia (MgO) in normal Portland cement, while still under investigation, can be considered harmless. Earlier investigators believed that as magnesia had a slower rate of hydration than lime, the hydration of any free magnesia (MgO) present would occur after the cement had set and cause disintegration.

The effect of magnesia was considered especially injurious when the cement was exposed to the action of sea water. More recent investigation has shown that cement can be made which is perfectly sound under all conditions when containing 5 per cent of magnesia and it has also been found that the lime in Portland cement exposed to sea water is replaced by magnesia.

The maximum limit for magnesia has been set at 4 per cent, as it has been established that this quantity is not injurious and it is high enough to permit the use of the large quantities of raw material available in most sections of the country.

PHYSICAL

Specific Gravity.—If the Le Chatelier apparatus is used for the determination of specific gravity, the clean volumenometer flask is filled with benzine free from water (which can be obtained by placing some calcium chloride or caustic lime in the benzine storage jar) to a point on the stem between zero and 1 cubic centimeter. The flask is then placed in a constant temperature bath until volume is constant. The usual method is to introduce 64 grams of cement into the flask, taking care that the powder does not adhere to the tube above the liquid, and to free the cement from air by rolling the flask in an inclined position. The flask is then replaced in the constant temperature bath until a constant volume is recorded.

The specific gravity is obtained from the formula:

$$\text{specific gravity} = \frac{\text{weight of cement in grams}}{\text{displaced volume in cu. cm.}}$$

The specific gravity of a Portland cement is not an indication of its cementing value. It will vary with the constituents of the cement, especially with the content of iron oxide. Thus the white or very light Portland cements, containing only a fraction of a per cent. of iron oxide, usually have a comparatively low specific gravity ranging from 3.05 to 3.15, while a cement containing 3 to 4 per cent. or more of iron oxide may have a specific gravity of 3.20 or even higher. It is materially affected by the temperature and duration of burning the cement, the hard-burned cement having the higher specific gravity. A comparatively low specific gravity does not necessarily indicate that a cement is underburned or adulterated, as large percentages of raw materials could be added to a cement with a normally high specific gravity before the gravity would be reduced below 3.10.

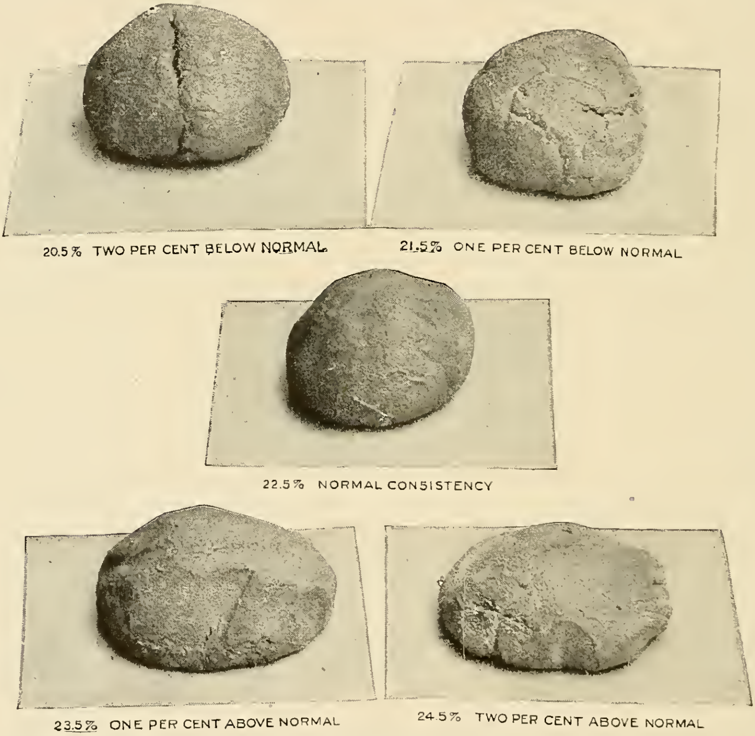
If a Portland cement fresh from the mill normally has a comparatively low specific gravity, upon aging it may absorb sufficient moisture and carbon dioxide to reduce the gravity below 3.10. It has been found that this does not appreciably affect the cementing value of the material; in fact, many cements are unsound until they have been aged. Thus a redetermination is permitted upon a sample heated to a temperature sufficient to drive off any moisture which may be absorbed by the cement subsequent to manufacturing, but would not drive off any carbon dioxide nor correct underburning in the process of manufacturing the cement.

The value of the specific gravity determination lies in the fact that it is easily made in the field or laboratory, and when the normal specific gravity of the cement is known, any considerable variation in quality due to underburning or the addition of foreign materials may be detected.

Fineness.—Only the extremely fine powder of cement called flour possesses appreciable cementing qualities and the coarser particles are practically inert. No sieve is fine enough to determine the flour in a cement, nor is there any other means of accurately and practically measuring the flour. Some cements grind easier than others, thus, although a larger percentage of one cement may pass the 200-mesh sieve than another, the former may have a smaller percentage of actual flour due to the difference in the hardness and the character of the clinker, and the method used in grinding. Thus the cementing value of different cements can not be compared directly upon their apparent fineness through a 200-mesh sieve. With cement from the same mill, with similar clinker and grinding machinery, however, it is probable that the greater the percentage which passes the 200-mesh sieve the greater the percentage of flour in that particular cement.

Normal Consistency.—The quantity of water used in making the paste from which the pats for soundness, tests of setting, and the briquettes are made, is very important and may vitally affect the results obtained. The determination consists in measuring the quantity of water required to bring a cement to a certain state of plasticity.

In determining the normal consistency by the ball method, after mixing the paste it should be formed into a ball with as little working as possible and a new batch of cement should be mixed for each trial paste. In order to obtain just the requisite quantity of paste to form a ball 2 inches in diameter, a measure made from a pipe with a 2-inch inside diameter cut 1$\frac{1}{3}$ inches long will be found convenient. The section of pipe should be open at both ends, so that it can be pushed down onto the paste on the mixing table and the excess paste cut off with the trowel. The appearance of the ball using the correct percentage of water for normal consistency as compared with a less and greater quantity of water is shown in Fig. 1.



20.5% TWO PER CENT BELOW NORMAL

21.5% ONE PER CENT BELOW NORMAL

22.5% NORMAL CONSISTENCY

23.5% ONE PER CENT ABOVE NORMAL

24.5% TWO PER CENT ABOVE NORMAL

Fig. 1.—Appearance of Ball for Different Consistencies of Cement Paste

Mixing.—The homogeneity of the cement paste is dependent upon the thoroughness of the mixing, and this may have considerable influence upon the time of setting and the strength of the briquettes.

Soundness.—The purpose of this test is to detect those qualities in a cement which tend to destroy the strength and durability. Unsoundness is usually manifested by a change in volume which causes cracking, swelling, or disintegration. If the pat is not properly made, or if it is placed where it will be subject to any drying during the first 24 hours, it may develop what are known as shrinkage cracks, which are not an indication of unsoundness and should not be confused with disintegration cracks, as shown in Figs. 2 and 3. No shrinkage cracks should develop after the first 24 or 48 hours.

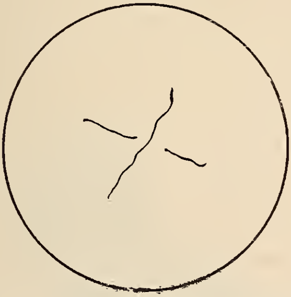


Fig. 2.—Soundness Pat Showing Shrinkage Cracks

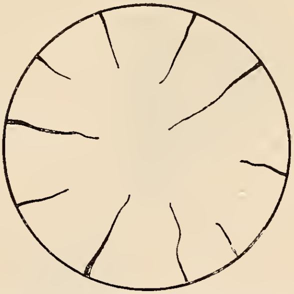


Fig. 3.—Soundness Pat Showing Disintegration Cracks

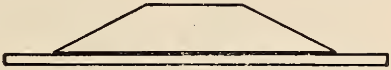


Fig. 5.—Soundness Pat with Top Surface Flattened for Determining Time of Setting

The failure of the pats to remain on the glass nor the cracking of the glass to which the pat is attached does not necessarily indicate unsoundness. In molding the pats, the cement paste should first be flattened on the glass and the pat formed by drawing the trowel from the outer edge toward the center, as shown in Fig. 4.

Time of Setting.—The purpose of this test is to determine the time which elapses from the moment water is added until the paste ceases to be plastic and the time required for it to obtain a certain degree of hardness. The determination of the "initial set" or when plasticity ceases is the more important, as a disturbance of the material after this time may cause a loss of strength and thus it is important that the mixing and molding or the incorporating of the material into the work be accomplished within this time. The time of setting is usually determined upon one of the pats which is to be used for the soundness test, the top surface being flattened somewhat, as shown in Fig. 5. In using the Gillmore needles care should be taken to apply the needles in a vertical position and perpendicular to the surface of the pat. Fig. 6 shows an arrangement for mounting the Gillmore needles so that they are always perpendicular to the surface of the pat. The rate of setting and hardening may be materially affected by slight changes in temperature. The percentage of water used in gauging and the humidity of the moist closet in which the test pieces are stored may also affect the setting somewhat.

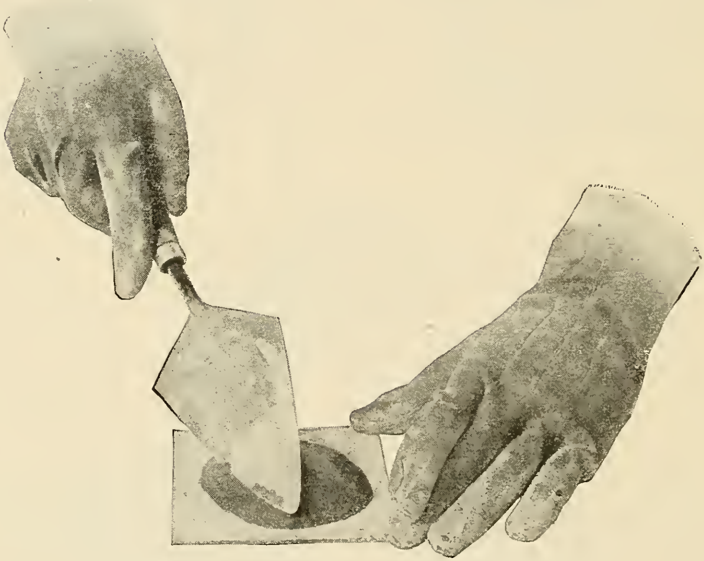


Fig. 4.—Correct Method of Molding Cement Pat

Tensile Tests.—Consistent results can only be obtained by exercising great care in molding and testing the briquettes. The correct method of filling the mold is shown in Figs. 7 and 8. In testing, the sides of the briquette and the clips should be thoroughly cleaned and free from grains of sand or dirt which would prevent a good bearing, and the briquette should be carefully centered in the clips so as to avoid cross strains. It may be considered good laboratory practice if the individual briquettes of any set do not show a greater variation from the mean value than 8 per cent for sand mixtures and 12 per cent for neat mixtures.

IV. AUXILIARY SPECIFICATIONS

Bureau of Standards Sieve Specifications

Wire cloth for standard sieves for cement and sand shall be woven (not twilled) from brass, bronze, or other suitable wire, and mounted on the frames without distortion.

The sieve frames shall be circular, about 20 centimeters (7.87 inches) in diameter, 6 centimeters (2.36 inches) high, and provided with a pan about 5 centimeters (1.97 inches) deep and a cover.

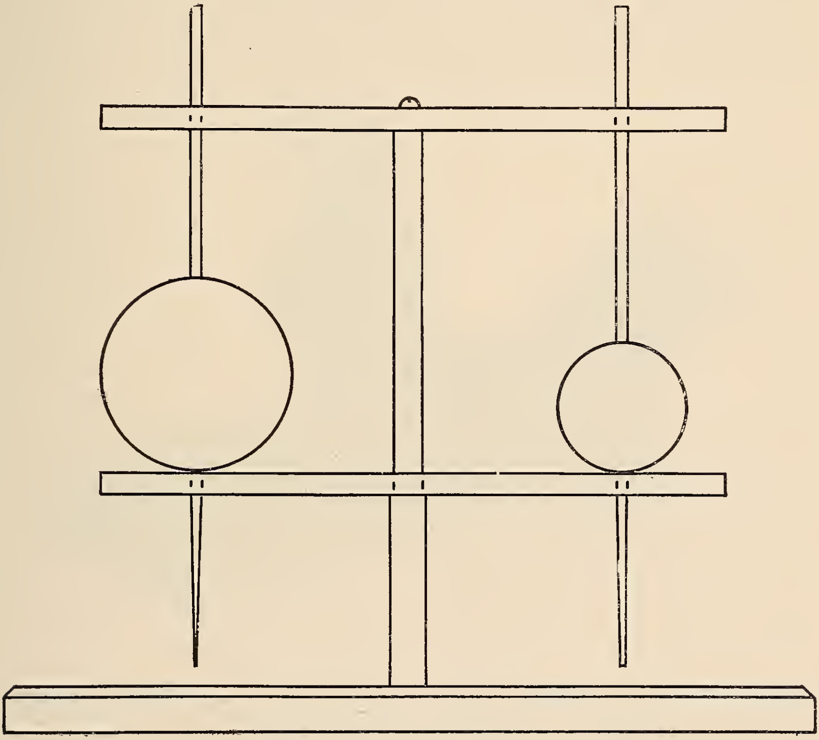


Fig. 6.—Method of Mounting Gillmore Needles

No. 100 Cement Sieve, 0.0055-Inch Opening.—The No. 100 sieve should have 100 wires per inch and shall conform to the following specifications of diameter of wire and size of mesh:

The diameter of the wires in the sieve should be 0.0045 inch and the average diameter of such wires as may be measured shall not be outside the limits 0.0042 to 0.0048 inch for either warp or shoot wires. The number of warp wires per whole inch, as measured at any point of the sieve, shall not be outside the limits 98 to 101 per inch, and of the shoot wires 96 to 102 per inch. For any interval of 0.25 to 0.50 inch in which the mesh may be measured the mesh shall not be outside the limits 95 to 101 wires per inch for the warp wires and 93 to 103 wires per inch for the shoot wires.

No. 200 Cement Sieve, 0.0029-Inch Opening.—The No. 200 sieve should have 200 wires per inch and shall conform to the following specifications of diameter of wire and size of mesh:

The diameter of the wires in the sieve should be 0.0021 inch, and the average diameter of such wires as may be measured shall not be outside the limits 0.0019 to 0.0023 inch for either warp or shoot wires. The number of warp wires per whole inch, as measured at any point of the sieve, shall not be outside the limits 195 to 202 per inch, and of the shoot wires 192 to 204 per inch. For any interval of 0.25 to 0.50 inch in which the mesh may be measured the mesh shall not be outside the limits 192 to 203 wires per inch for the warp wires and 190 to 205 wires per inch for the shoot wires.

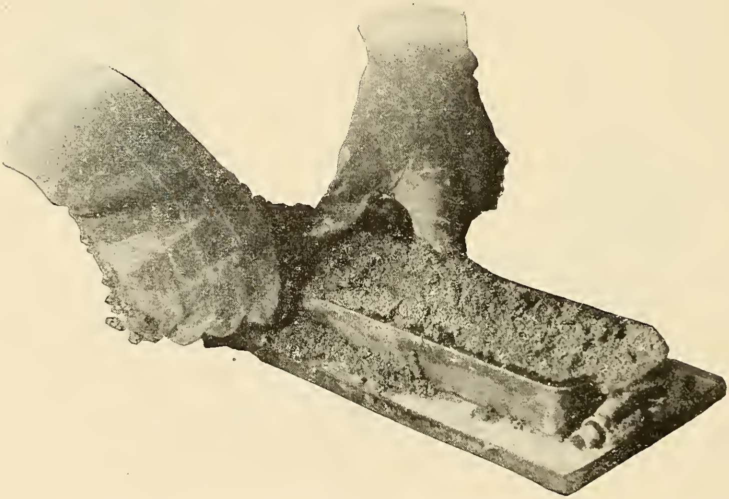


Fig. 7.—Correct Method of Filling Briquette Mold

No. 20 Sand Sieve, 0.0335-Inch Opening.—No. 20 sieves shall have between 19.5 and 20.5 wires per whole inch of the warp wires and between 19 and 21 wires per inch of the shoot wires. The diameter of the wire should be 0.0165 inch and the average as measured shall not vary outside the limits 0.0160 to 0.0170 inch.

No. 30 Sand Sieve, 0.0223-Inch Opening.—No. 30 sieves shall have between 29.5 and 30.5 wires per whole inch of the warp wires and between 28.5 and 31.5 per whole inch of the shoot wires. The diameter of the wire should be 0.0110 inch and the average as measured shall not vary outside the limits 0.0105 to 0.0115 inch.

BUREAU OF STANDARDS SPECIFICATION FOR SPECIFIC-GRAVITY FLASKS

Material and Annealing.—The material from which the flasks are made shall be glass of the best quality, transparent, and free from striæ. It shall adequately resist chemical action and have small thermal hysteresis. The flasks shall be thoroughly annealed at 400 ° C. to 500 ° C. for 24 hours and allowed to cool slowly before being graduated. They shall be of sufficient thickness to insure reasonable resistance to breakage.

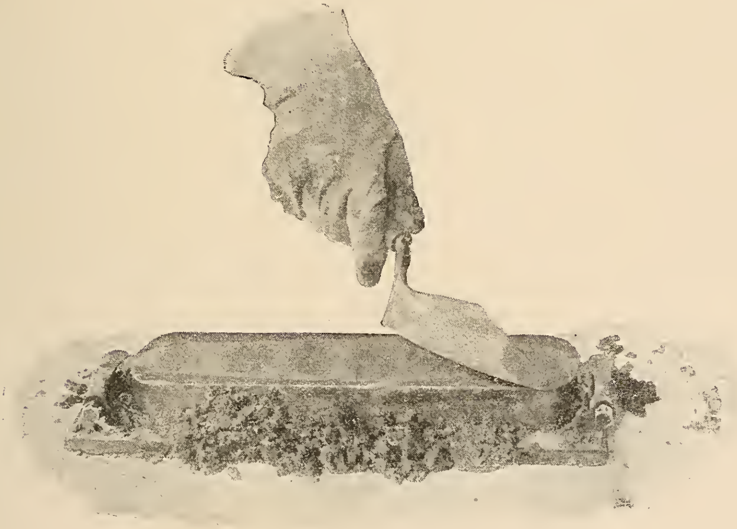


Fig. 8.—Correct Method of Troweling Surface of Briquettes

Design.—The cross-section of the flask shall be circular and the shape and dimensions shall conform to the diagram shown in Fig. 9. This design is intended to insure complete drainage of the flask on emptying and stability of standing on a level surface, as well as accuracy and precision of reading. The neck of the flask shall be cylindrical for at least 1 centimeter above and below every graduation mark. There shall be a space of at least 1 centimeter between the highest graduation mark and the lowest point of the grinding for the glass stopper.

Capacity.—The flask should contain approximately 250 c.c. when filled to the zero graduation mark.

Graduations.—The neck shall be graduated from 0 to 1 c.c.

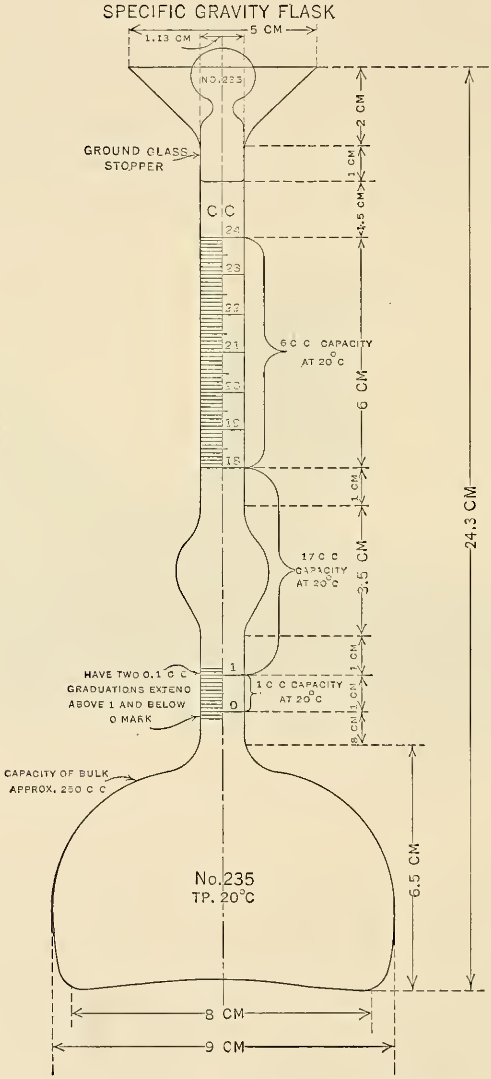


Fig. 9.—Diagram Showing Form and Dimensions of Specific-Gravity Flask

and from 18 c.c. to 24 c.c. into 0.1-c.c. divisions. The 0.1-c.c. graduations should be continued two below the 0 and two above the 1-c.c. graduation. The graduations shall be of uniform width, finely but distinctly etched, and shall be perpendicular to the axis of the flask. The 0.1-c.c. graduations shall be at least 1 millimeter apart. This will require an internal diameter of the neck not greater than 11.3 millimeters. The 1-c.c. graduations shall extend completely around the neck of the flask and shall be numbered to indicate the capacity. The 0.1-c.c. graduations shall extend at least halfway around the neck and the 0.5-c.c. graduations shall have a length about midway between the other two. The graduation marks shall have no apparent irregularities of spacing.

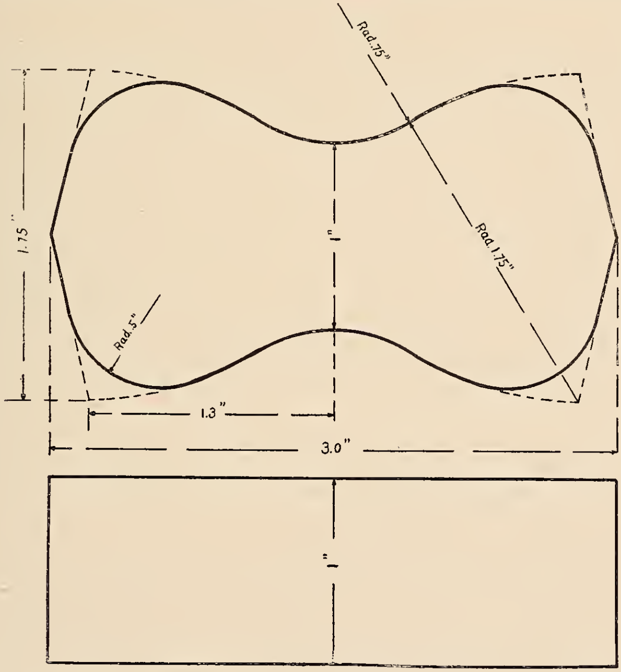


Fig. 10.—Form of Briquette as Recommended by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers

Standard Temperature.—The flasks shall be standard at 20° C. The indicated specific gravities will then be at 20° referred to water at 4° as unity—that is, density at 20° in grams per c.c.

Inscriptions.—Each flask shall bear a permanent identification number and the stopper shall bear the same number. The standard temperature shall be indicated and the unit of capacity shall be shown by the letters "c.c." placed above the highest graduation mark.

Tolerance.—The error of any indicated capacity shall not be greater than 0.05 c.c.

Interpretation of Specification.—The foregoing specification is intended to represent the most desirable form of specific gravity flask for use in testing cements. Variations of a few millimeters in such dimensions as total height of flask, diameter of base, etc., are to be expected and will not be considered sufficient cause for rejection. The specification in regard to tolerance, inscriptions, length, spacing, and uniformity of graduations will, however, be rigidly enforced.

STANDARD SPECIFICATIONS FOR CEMENT.

As Adopted August 16, 1909, by the American Society for Testing Materials.

General Observations.

1. These remarks have been prepared with a view of pointing out the pertinent features of the various requirements and the precautions to be observed in the interpretation of the results of the tests.

2. The Committee would suggest that the acceptance or rejection under these specifications be based on tests made by an experienced person having the proper means for making the tests.

Specific Gravity.—3. Specific gravity is useful in detecting adulteration. The results of tests of specific gravity are not necessarily conclusive as an indication of the quality of a cement, but when in combination with the results of other tests may afford valuable indications.

Fineness.—4. The sieves should be kept thoroughly dry.

Time of Setting.—5. Great care should be exercised to maintain the test pieces under as uniform conditions as possible. A sudden change or wide range of temperature in the room in which the tests are made, a very dry or humid atmosphere, and other irregularities vitally affect the rate of setting.

Constancy of Volume.—6. The tests for constancy of volume are divided into two classes, the first normal, the second accelerated. The latter should be regarded as a precautionary test only, and not infallible. So many conditions enter into the making and interpreting of it that it should be used with extreme care.

7. In making the pats the greatest care should be exercised to avoid initial strains due to molding or to too rapid drying-out during the first twenty-four hours. The pats should be preserved under the most uniform conditions possible, and rapid changes of temperature should be avoided.

8. The failure to meet the requirements of the accelerated tests need not be sufficient cause for rejection. The cement may,

however, be held for 28 days, and a retest made at the end of that period using a new sample. Failure to meet the requirements at this time should be considered sufficient cause for rejection, although in the present state of our knowledge it cannot be said that such failure necessarily indicates unsoundness, nor can the cement be considered entirely satisfactory simply because it passes the tests.

Specifications.

General Conditions.—1. All cement shall be inspected.

2. Cement may be inspected either at the place of manufacture or on the work.

3. In order to allow ample time for inspecting and testing, the cement should be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the contractor and a period of at least 12 days allowed for the inspection and necessary tests.

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 pounds of cement net. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

8. Cement failing to meet the 7-day requirements may be held awaiting the results of the 28-day tests before rejection.

9. All tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the Society January 21, 1903, amended January 20, 1904, and January 15, 1908, with all subsequent amendments thereto.*

10. The acceptance or rejection shall be based on the following requirements:

Natural Cement.—11. *Definition.* This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Fineness.—12. It shall leave by weight a residue of not more than 10 per cent on the No. 100, and 30 per cent on the No. 200 sieve.

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*See pp. 7–22.—Ed.

Time of Setting.—13. It shall not develop initial set in ~~not~~ less than 10 minutes, and shall not develop hard set in ~~not~~ less than 30 minutes, or in more than 3 hours.

Tensile Strength.—14. The minimum requirements for tensile strength for briquettes 1 square inch in cross section shall be as follows, and the cement shall show no retrogression in strength within the periods specified:

Age.	*Neat Cement.*	*Strength.*
24 hours in moist air		75 lbs.
7 days (1 day in moist air, 6 days in water)		150 "
28 days (1 day in moist air, 27 days in water)		250 "
	One Part Cement, Three Parts Standard Ottawa Sand.	
7 days (1 day in moist air, 6 days in water)		50 "
28 days (1 day in moist air, 27 days in water)		125 "

Constancy of Volume.—15. Pats of neat cement about 3 inches in diameter, one-half inch thick at center, tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(*a*) A pat is then kept in air at normal temperature.

(*b*) Another is kept in water maintained as near 70° F. as practicable.

16. These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, ~~should~~ remain firm and hard Shal and show no signs of distortion, checking, cracking or disintegrating.

Portland Cement.—17. *Definition.* This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 per cent has been made subsequent to calcination.

Specific Gravity.—18. The specific gravity of cement shall be not less than 3.10. Should the test of cement as received fall below this requirement, a second test may be made upon a sample ignited at low red heat. The loss in weight of the ignited cement shall not exceed 4 per cent.

Fineness.—19. It shall leave by weight a residue of not more than 8 per cent on the No. 100, and not more than 25 per cent on the No. 200 sieve.

Time of Setting.—20. It shall not develop initial set in ~~not~~ less than 30 minutes, and must develop hard set in not less than 1 hour, nor more than 10 hours.

Tensile Strength.—21. The minimum requirements for tensile strength for briquettes 1 square inch in cross section shall be as follows, and the cement shall show no retrogression in strength within the periods specified:

Age.	*Strength.*
Neat Cement.	
24 hours in moist air	175 lbs.
7 days (1 day in moist air, 6 days in water)	500 "
28 days (1 day in moist air, 27 days in water)	600 "
One Part Cement, Three Parts Standard Ottawa Sand	
7 days (1 day in moist air, 6 days in water)	200 lbs.
28 days (1 day in moist air, 27 days in water)	275 "

Constancy of Volume.—22. Pats of neat cement about 3 inches in diameter, one-half inch thick at the center, and tapering to a thin edge shall be kept in moist air for a period of 24 hours.

(*a*) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(*b*) Another pat is kept in water maintained as near 70 ° F. as practicable, and observed at intervals for at least 28 days.

(*c*) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for 5 hours.

23. These pats, to satisfactorily pass the requirements, shall remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Sulphuric Acid and Magnesia.—24. The cement shall not contain more than 1.75 per cent. of anhydrous sulphuric acid (SO_3), nor more than 4 per cent of magnesia (MgO).

METHODS FOR TESTING CEMENT. *

REPORT OF THE COMMITTEE OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, PRESENTED AT THE ANNUAL MEETING, JANUARY 17, 1912.

Sampling.

1. **Selection of Sample.**—The selection of samples for testing should be left to the engineer. The number of packages sampled and the quantity taken from each package will depend on the importance of the work and the facilities for making the tests.

2. The samples should fairly represent the material. When the amount to be tested is small it is recommended that 1 barrel in 10 be sampled; when the amount is large it may be impracticable to take samples from more than 1 barrel in 30 or 50. When the samples are taken from bins at the mill 1 for each 50 to 200 barrels will suffice.

3. Samples should be passed through a sieve having 20 meshes per linear inch, in order to break up lumps and remove foreign material; the use of this sieve is also effective to obtain a thorough mixing of the samples when this is desired. To determine the acceptance or rejection of cement it is preferable, when time permits, to test the samples separately. Tests to determine the general characteristics of a cement, extending over a long period, may be made with mixed samples.

4. **Method of Sampling.**—Cement in barrels should be sampled through a hole made in the head, or in one of the staves midway between the heads, by means of an auger or a sampling iron similar to that used by sugar inspectors; if in bags, the sample should be taken from surface to center; cement in bins should be sampled in such a manner as to represent fairly the contents of the bin. Sampling from bins is not recommended if the method of manufacture is such that ingredients of any kind are added to the cement subsequently.

Chemical Analysis

5. **Significance.**—Chemical analysis may serve to detect adul-

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* Accompanying Final Report of Special Committee of American Society of Civil Engineers on Uniform Tests of Cement, dated January 17th, 1912.

teration of cement with inert material, such as slag or ground limestone, if in considerable amount. It is useful in determining whether certain constituents, such as magnesia and sulphuric anhydride, are present in inadmissible proportions.

6. The determination of the principal constituents of cement, silica, alumina, iron oxide, and lime, is not conclusive as an indication of quality. Faulty cement results more frequently from imperfect preparation of the raw material or defective burning than from incorrect proportions. Cement made from material ground very finely and thoroughly burned may contain much more lime than the amount usually present, and still be perfectly sound. On the other hand, cements low in lime may, on account of careless preparation of the raw material, be of dangerous character. Furthermore, the composition of the product may be so greatly modified by the ash of the fuel used in burning as to affect in a great degree the significances of the results of analysis.

7. **Methods.**—The methods to be followed, except for determining the loss on ignition, should be those proposed by the Committee on Uniformity in the Analysis of Materials for the Portland Cement Industry, reported in the *Journal* of the Society for Chemical Industry, Vol. 21, page 12, 1902; and published in *Engineering News*, Vol. 50, page 60, 1903; and in *Engineering Record*, Vol. 48, page 49, 1903, and in addition thereto, the following:

(*a*) The insoluble residue may be determined as follows: To a 1-gram sample of cement are added 30 cu. cm. of water and 10 cu. cm. of concentrated hydrochloric acid, and then warmed until effervescence ceases, and digested on a steam bath until dissolved. The residue is filtered, washed with hot water, and the filter paper and contents digested on the steam bath in a 5% solution of sodium carbonate. This residue is filtered, washed with hot water, then with hot hydrochloric acid, and finally with hot water, and then ignited at a red heat and weighed. The quantity so obtained is the insoluble residue.

(*b*) The loss on ignition shall be determined in the following manner: ½ gram of cement is heated in a weighed platinum crucible, with cover, for 5 minutes with a Bunsen burner (starting with a low flame and gradually increasing to its full height) and then heated for 15 minutes with a blast lamp: the difference between the weight after cooling and the original weight is the loss on ignition. The temperature should not exceed 900° cent. or a low red heat; the ignition should preferably be made in a muffle.

SPECIFIC GRAVITY.

8. **Significance.**—The specific gravity of cement is lowered by adulteration and hydration, but the adulteration must be considerable to be detected by tests of specific gravity.

9. Inasmuch as the differences in specific gravity are usually very small, great care must be exercised in making the determination.

10. **Apparatus.**—The determination of specific gravity should be made with a standardized Le Chatelier apparatus. This consists of a flask (*D*), Fig. 1, of about 120 cu. cm. capacity, the neck of which is about 20 cm. long; in the middle of this neck is a bulb (*C*), above and below which are two marks (*F*) and (*E*); the volume between these two marks is 20 cu. cm. The neck has a diameter of about 9 mm., and is graduated into tenths of cubic centimeters above the mark (*F*).

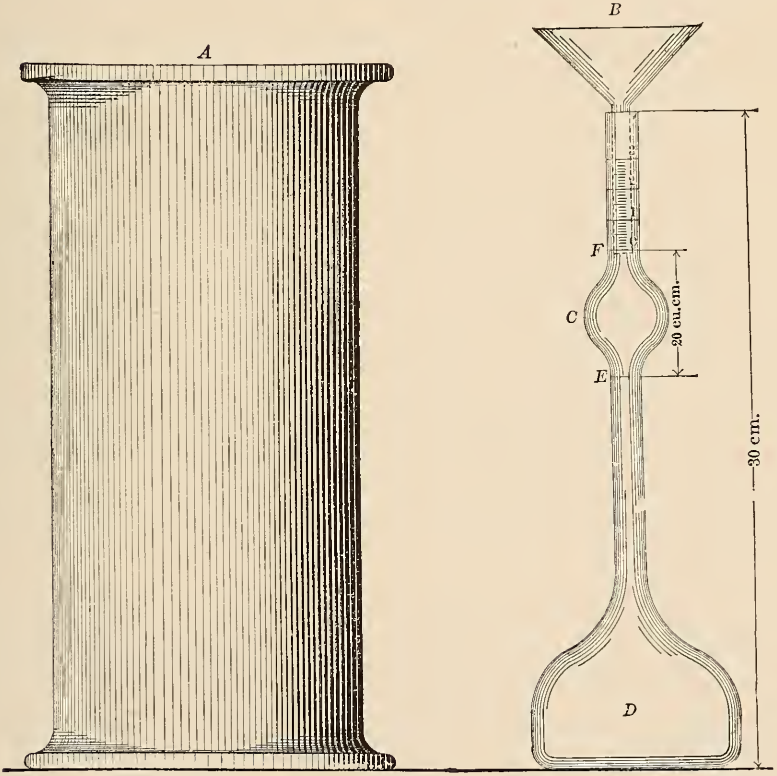

Fig. 1.—Le Chatelier's Specific-Gravity Apparatus.

11. Benzine (62° Baumè naphtha) or kerosene free from water should be used in making the determination.

12. **Method.**—The flask is filled with either of these liquids to the lower mark (*E*), and 64 grams of cement, cooled to the temperature of the liquid, is slowly introduced through the funnel (*B*) (the stem of which should be long enough to extend into the flask to the top of the bulb (*C*), taking care that the cement does not adhere to the sides of the flask, and that the funnel does not touch the liquid. After all the cement is introduced, the level of the liquid will rise to some division of the graduated neck; this reading, plus 20 cu. cm., is the volume displaced by 64 grams of the cement.

13. The specific gravity is then obtained from the formula

$$\text{Specific gravity} = \frac{\text{Weight of cement, in grams,}}{\text{Displaced volume, in cubic centimeters.}}$$

14. The flask, during the operation, is kept immersed in water in a jar (*A*), in order to avoid variation in the temperature of the liquid in the flask, which should not exceed ½° cent. The results of repeated tests should agree within 0.01. The determination of specific gravity should be made on the cement as received; if it should fall below 3.10, a second determination should be made after igniting the sample in a covered dish, preferably of platinum, at a low red heat not exceeding 900° cent. The sample should be heated for 5 minutes with a Bunsen burner (starting with a low flame and gradually increasing to its full height) and then heated for 15 minutes with a blast lamp; the ignition should preferably be made in a muffle.

15. The apparatus may be cleaned in the following manner: The flask is inverted and shaken vertically until the liquid flows freely, and then held in a vertical position until empty; any traces of cement remaining can be removed by pouring into the flask a small quantity of clean liquid benzine or kerosene and repeating the operation.

Fineness.

16. **Significance.**—It is generally accepted that the coarser particles in cement are practically inert, and it is only the extremely fine powder that possesses cementing qualities. The more finely cement is pulverized, other conditions being the same, the more sand it will carry and produce a mortar of a given strength.

17. **Apparatus.**—The fineness of a sample of cement is determined by weighing the residue retained on certain sieves. Those known as No. 100 and No. 200, having approximately 100 and 200

wires per linear inch, respectively, should be used. They should be 8 inches in diameter. The frame should be of brass, 8 inches in diameter, and the sieve of brass wire cloth conforming to the following requirements:

No. of sieve.	Diameter of wire.	Meshes per Linear Inch.	
		Warp.	Woof.
100	0.0042 to 0.0048 in.	95 to 101	93 to 103
200	0.0021 to 0.0023 "	192 to 203	190 to 205

The meshes in any smaller space, down to 0.25 inch, should be proportional in number.

18. **Method.**—The test should be made with 50 grams of cement, dried at a temperature of 100° cent. (212° Fahr.).

19. The cement is placed on the No. 200 sieve, which, with pan and cover attached, is held in one hand in a slightly inclined position, and moved forward and backward about 200 times per minute, at the same time striking the side gently, on the up stroke, against the palm of the other hand. The operation is continued until not more than 0.05 gram will pass through in one minute. The residue is weighed, then placed on the No. 100 sieve, and the operation repeated. The work may be expedited by placing in the sieve a few large steel shot, which should be removed before the final one minute of sieving. The sieves should be thoroughly dry and clean.

Normal Consistency.

20. **Significance.**—The use of a proper percentage of water in making pastes* and mortars for the various tests is exceedingly important and affects vitally the results obtained.

21. The amount of water, expressed in percentage by weight of the dry cement, required to produce a paste of plasticity desired, termed "normal consistency," should be determined with the Vicat apparatus in the following manner:

22. **Apparatus.**—This consists of a frame (*A*), Fig. 2, bearing a movable rod (*B*), weighing 300 grams, one end (*C*) being 1 cm. in diameter for a distance of 6 cm., the other having a removable needle (*D*), 1 mm. in diameter, 6 cm. long. The rod is reversible,

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*The term "paste" is used in this report to designate a mixture of cement and water, and the word "mortar" to designate a mixture of cement, sand, and water.

and can be held in any desired position by a screw (*E*), and has midway between the ends a mark (*F*) which moves under a scale (graduated to millimeters) attached to the frame (*A*). The paste is held in a conical, hard-rubber ring (*G*), 7 cm. in diameter at the base, 4 cm. high, resting on a glass plate (*H*) about 10 cm. square.

23. **Method.**—In making the determination, the same quantity of cement as will be used subsequently for each batch in making the test pieces, but not less than 500 grams, with a measured quantity of water, is kneaded into a paste, as described in Paragraph 45, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained about 6 inches apart; the ball resting in the palm of one hand is pressed into the larger end of the rubber ring held in the other hand, completely filling the ring with paste; the excess at the larger end is then removed by a single movement of the palm of the hand; the

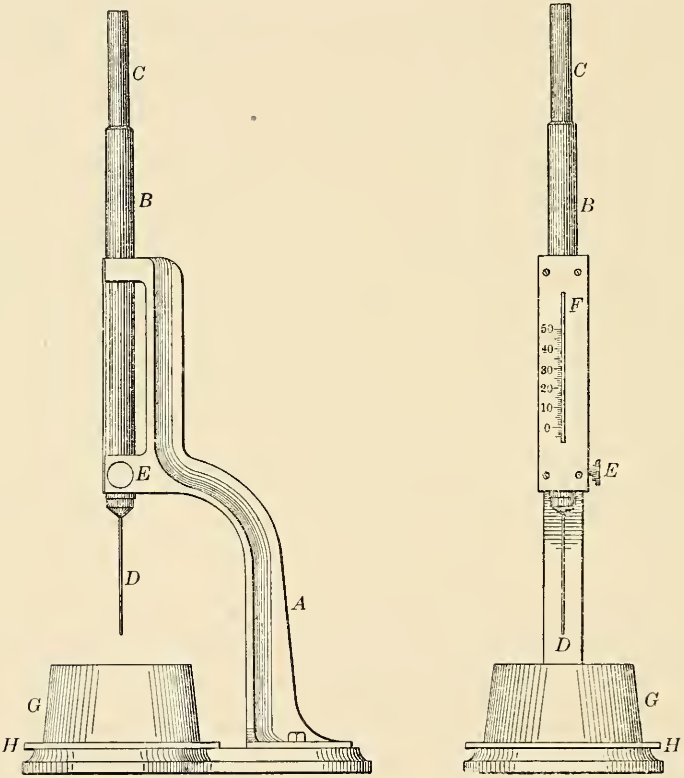

Fig. 2.—Vicat Apparatus.

ring is then placed on its larger end on a glass plate and the excess paste at the smaller end is sliced off at the top of the ring by a single oblique stroke of a trowel held at a slight angle with the top of the ring. During these operations care must be taken not to compress the paste. The paste confined in the ring, resting on the plate, is placed under the rod, the larger end of which is brought in contact with the surface of the paste; the scale is then read, and the rod quickly released.

24. The paste is of normal consistency when the cylinder settles to a point 10 mm. below the original surface in one-half minute after being released. The apparatus must be free from all vibrations during the test.

25. Trial pastes are made with varying percentages of water until the normal consistency is obtained.

26. Having determined the percentage of water required to produce a paste of normal consistency, the percentage required for a mortar containing, by weight, one part of cement to three parts of standard Ottawa sand, is obtained from the following table, the amount being a percentage of the combined weight of the cement and sand.

PERCENTAGE OF WATER FOR STANDARD MORTARS.

Neat.	One cement, three standard Ottawa sand.	Neat.	One cement, three standard Ottawa sand.	Neat.	One cement, three standard Ottawa sand.
15	8.0	23	9.3	31	10.7
16	8.2	24	9.5	32	10.8
17	8.3	25	9.7	33	11.0
18	8.5	26	9.8	34	11.2
19	8.7	27	10.0	35	11.3
20	8.8	28	10.2	36	11.5
21	9.0	29	10.3	37	11.7
22	9.2	30	10.5	38	11.8

TIME OF SETTING.

27. **Significance.**—The object of this test is to determine the time which elapses from the moment water is added until the paste ceases to be plastic (called the "initial set"), and also the time until it acquires a certain degree of hardness (called the "final set" or "hard set"). The former is the more important, since, with the commencement of setting, the process of crystallization begins. As a disturbance of this process may produce a loss of strength, it is desirable to complete the operation of mixing or moulding or incorporating the mortar into the work before the cement begins to set.

28. **Apparatus.**—The initial and final set should be determined with the Vicat apparatus described in Paragraph 22.

29. **Method.**—A paste of normal consistency is moulded in the hard-rubber ring, as described in Paragraph 23, and placed under the rod (*B*), the smaller end of which is then carefully brought in contact with the surface of the paste, and the rod quickly released.

30. The initial set is said to have occurred when the needle ceases to pass a point 5 mm. above the glass plate; and the final set, when the needle does not sink visibly into the paste.

31. The test pieces should be kept in moist air during the test; this may be accomplished by placing them on a rack over water contained in a pan and covered by a damp cloth; the cloth to be kept from contact with them by means of a wire screen; or they may be stored in a moist box or closet.

32. Care should be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point may increase the penetration.

33. The time of setting is affected not only by the percentage and temperature of the water used and the amount of kneading the paste receives, but by the temperature and humidity of the air, and its determination is, therefore, only approximate.

STANDARD SANDS.

34. The sand to be used should be natural sand from Ottawa, Ill., screened to pass a No. 20 sieve, and retained on a No. 30 sieve. The sieves should be at least 8 in. in diameter; the wire cloth should be of brass wire and should conform to the following requirements:

No. of sieve.	Diameter of wire.	MESHES PER LINEAR INCH.	
		Warp.	Woof.
20	0.016 to 0.017 in.	19.5 to 20.5	19 to 21
30	0.011 to 0.012 "	29.5 to 30.5	28.5 to 31.5

Sand which has passed the No. 20 sieve is standard when not more than 5 grams passes the No. 30 sieve in one minute of continuous sifting of a 500-gram sample.*

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*This sand may now (1912) be obtained from the Ottawa Silica Co., at a cost of two cents per pound, f.o.b. cars, Ottawa, Ill.

Form of Test Pieces.

35. For tensile tests the form of test piece shown in Fig. 3 should be used.

36. For compressive tests, 2-inch cubes should be used.

Moulds.

37. The moulds should be of brass, bronze, or other non-corrodible material, and should have sufficient metal in the sides to prevent spreading during moulding.

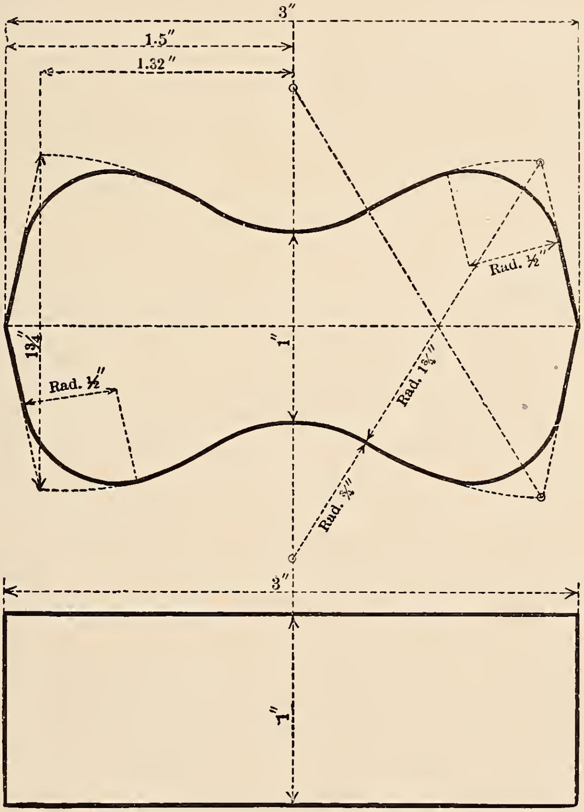


Fig. 3.—Details for Briquette.

38. Moulds may be either single or gang moulds. The latter are preferred by many. If used, the types shown in Figs. 4 and 5 are recommended.

39. The moulds should be wiped with an oily cloth before using.

MIXING.

40. The proportions of sand and cement should be stated by weight; the quantity of water should be stated as a percentage by weight of the dry material.

41. The metric system is recommended because of the convenient relation of the gram and the cubic centimeter.

42. The temperature of the room and of the mixing water should be maintained as nearly as practicable at 21° cent. (70° Fahr.).

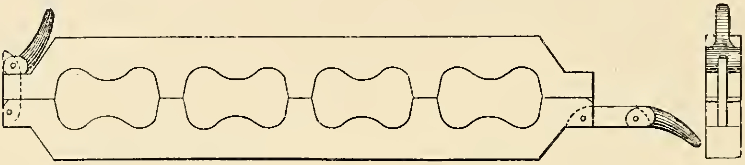


Fig. 4.—Details for Gang Mould.

43. The quantity of material to be mixed at one time depends on the number of test pieces to be made; 1000 grams is a convenient quantity to mix by hand methods.

44. The Committee has investigated the various mechanical mixing machines thus far devised, but cannot recommend any of them, for the following reasons: (1) the tendency of most cement is to "ball up" in the machine, thereby preventing working it into a homogeneous paste; (2) there are no means of ascertaining when the mixing is complete without stopping the machine; and (3) it is difficult to keep the machine clean.

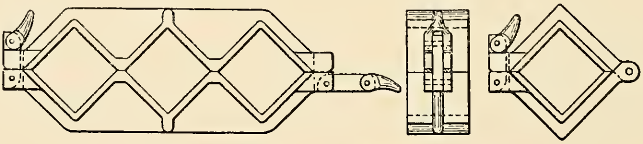


Fig. 5.—Mould for Compression Test Pieces.

45. **Method.**—The material is weighed, placed on a non-absorbent surface (preferably plate glass), thoroughly mixed dry if sand be used, and a crater formed in the center, into which the proper percentage of clean water is poured; the material on the outer edge is turned into the center by the aid of a trowel. As soon as the water has been absorbed, which should not require more than one minute, the operation is completed by vigorously kneading

with the hands for one minute. During the operation the hands should be protected by rubber gloves.

MOULDING.

46. The Committee has not been able to secure satisfactory results with existing moulding machines; the operation of machine moulding is very slow; and is not practicable with pastes or mortars containing as large percentages of water as herein recommended.

47. **Method.**—Immediately after mixing, the paste or mortar is placed in the moulds with the hands, pressed in firmly with the fingers, and smoothed off with a trowel without ramming. The material should be heaped above the mould, and, in smoothing off, the trowel should be drawn over the mould in such a manner as to exert a moderate pressure on the material. The mould should then be turned over and the operation of heaping and smoothing off repeated.

48. A check on the uniformity of mixing and moulding may be afforded by weighing the test pieces on removal from the moist closet; test pieces from any sample which vary in weight more than 3 per cent from the average should not be considered.

STORAGE OF THE TEST PIECES.

49. During the first 24 hours after moulding, the test pieces should be kept in moist air to prevent drying.

50. Two methods are in common use to prevent drying: (1) covering the test pieces with a damp cloth, and (2) placing them in a moist closet. The use of the damp cloth, as usually carried out, is objectionable, because the cloth may dry out unequally and in consequence the test pieces will not all be subjected to the same degree of moisture. This defect may be remedied to some extent by immersing the edges of the cloth in water; contact between the cloth and the test pieces should be prevented by means of a wire screen or some similar arrangement. A moist closet is so much more effective in securing uniformly moist air, and is so easily devised and so inexpensive, that the use of the damp cloth should be abandoned.

51. A moist closet consists of a soapstone or slate box, or a wooden box lined with metal, the interior surface being covered with felt or broad wicking kept wet, the bottom of the box being kept covered with water. The interior of the box is provided with glass shelves on which to place the test pieces, the shelves being so arranged that they may be withdrawn readily.

52. After 24 hours in moist air, the pieces to be tested after

longer periods should be immersed in water in storage tanks or pans made of non-corrodible material.

53. The air and water in the moist closet and the water in the storage tanks should be maintained as nearly as practicable at 21° cent. (70° Fahr.).

Tensile Strength.

54. The tests may be made with any standard machine.

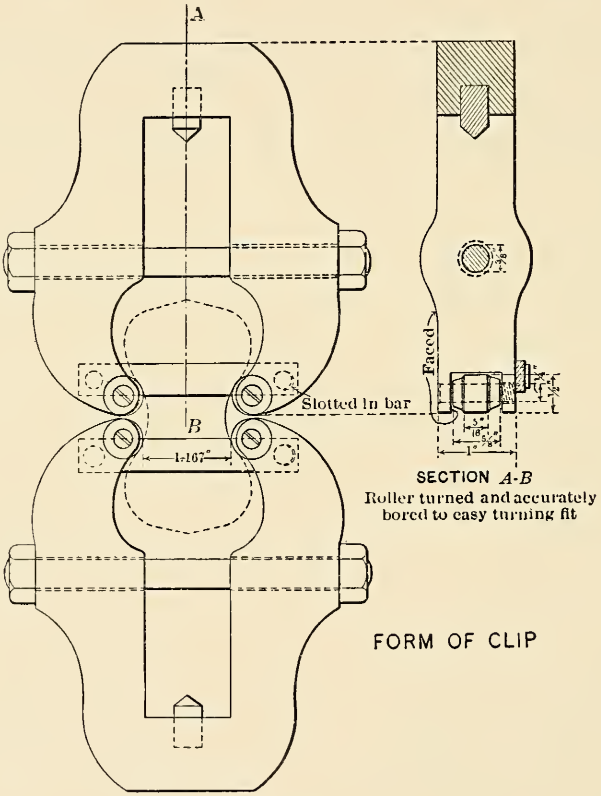


Fig. 6

55. The clip is shown in Fig. 6. It must be made accurately, the pins and rollers turned, and the rollers bored slightly larger than the pins so as to turn easily. There should be a slight clearance at each end of the roller, and the pins should be kept properly lubricated and free from grit. The clips should be used without cushioning at the points of contact.

56. Test pieces should be broken as soon as they are removed from the water. Care should be observed in centering the test pieces in the testing machine, as cross strains, produced by imperfect centering, tend to lower the breaking strength. The load should not be applied too suddenly, as it may produce vibration, the shock from which often causes the test piece to break before the ultimate strength is reached. The bearing surfaces of the clips and test pieces must be kept free from grains of sand or dirt, which would prevent a good bearing. The load should be applied at the rate of 600 lbs. per min. The average of the results of the test pieces from each sample should be taken as the test of the sample. Test pieces which do not break within $\frac{1}{4}$ in. of the center, or are otherwise manifestly faulty, should be excluded in determining average results.

COMPRESSIVE STRENGTH.

57. The tests may be made with any machine provided with means for so applying the load that the line of pressure is along the axis of the test piece. A ball-bearing block for this purpose is shown in Fig. 7. Some appliance should be provided to facilitate placing the axis of the test pieces exactly in line with the center of the ball-bearing.

58. The test piece should be placed in the testing machine, with a piece of heavy blotting paper on each of the crushing faces, which should be those that were in contact with the mould.

CONSTANCY OF VOLUME.

59. **Significance.**—The object is to detect those qualities which tend to destroy the strength and durability of a cement. Under normal conditions these defects will in some cases develop quickly, and in other cases may not develop for a considerable time. Since the detection of these destructive qualities before using the cement in construction is essential, tests are made not only under normal conditions but under artificial conditions created to hasten the development of these defects. Tests may, therefore, be divided into two classes: (1) Normal tests, made in either air or water maintained, as nearly as practicable, at 21° cent. (70° Fahr.) ; and (2) Accelerated tests, made in air, steam or water, at temperatures of 45° cent. (113° Fahr.) and upward. The Committee recommends that these tests be made in the following manner:

60. **Methods.**—Pats, about 3 inches in diameter, $\frac{1}{2}$ in. thick at the center, and tapering to a thin edge, should be made on clean

glass plates (about 4 in. square) from cement paste of normal consistency, and stored in a moist closet for 24 hours.

61. **Normal Tests.**—After 24 hours in the moist closet, a pat is immersed in water for 28 days and observed at intervals. A similar pat, after 24 hours in the moist closet, is exposed to the air for 28 days or more and observed at intervals.

62. **Accelerated Test.**—After 24 hours in the moist closet, a pat is placed in an atmosphere of steam, upon a wire screen 1 in. above boiling water, for 5 hours. The apparatus should be so constructed that the steam will escape freely and atmospheric pressure be maintained. Since the type of apparatus used has a great influence on the results, the arrangement shown in Fig. 8 is recommended.

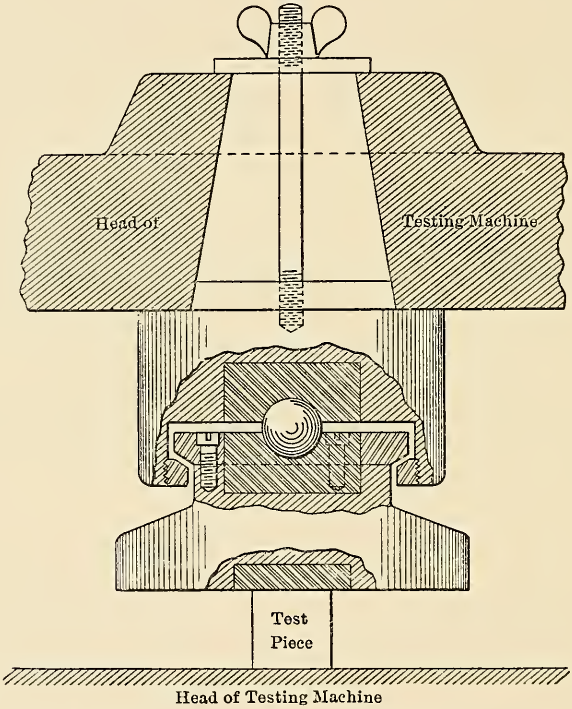
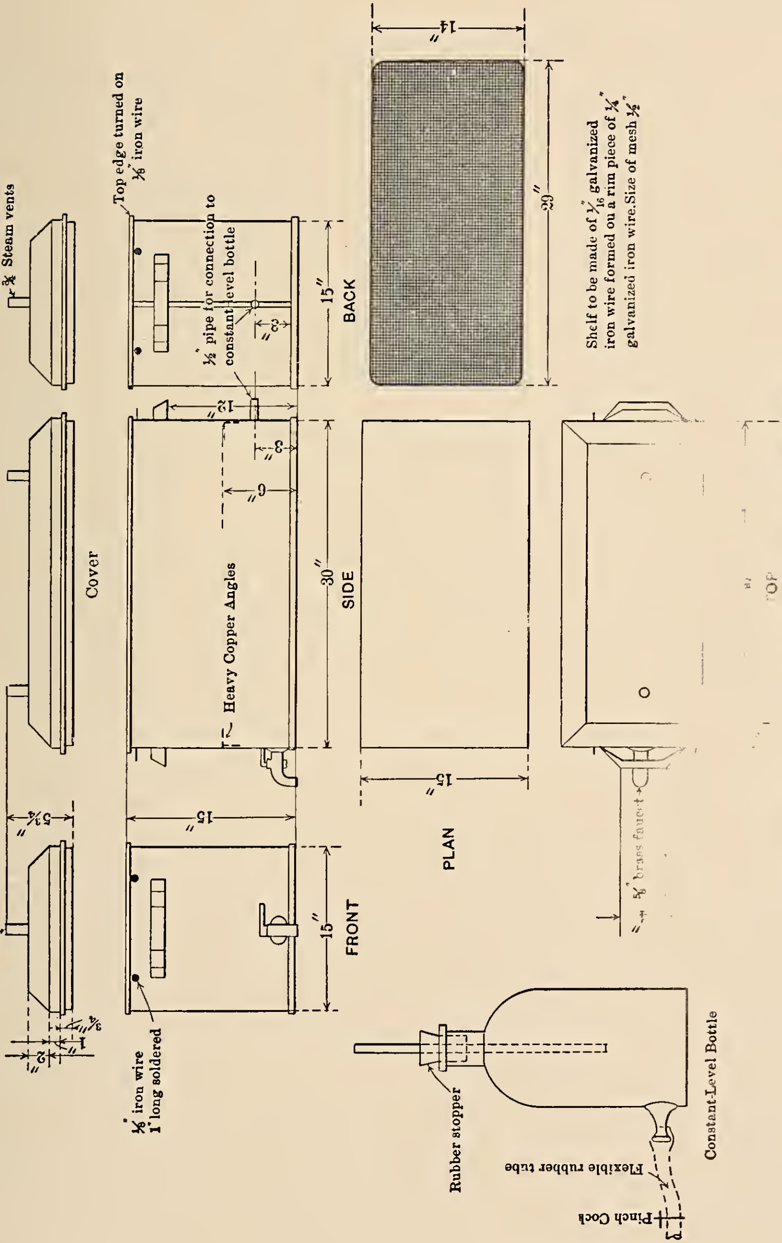


Fig. 7.—Ball-bearing Block for Testing Machine.

63. Pats which remain firm and hard and show no signs of cracking, distortion, or disintegration are said to be "of constant volume" or "sound."

64. Should the pat leave the plate, distortion may be detected

APPARATUS FOR MAKING ACCELERATED TEST FOR SOUNDNESS OF CEMENT.


¾" Steam vents
¾" Steam vents
Cover
5¾"
2"
1"
⅜"
Top edge turned on ⅛" iron wire
½" pipe for connection to constant level bottle
⅛" iron wire 1" long soldered
12"
3"
3"
6"
2"
Heavy Copper Angles
15"
15"
30"
15"
BACK
SIDE
FRONT
14"
29"
Shelf to be made of 1/16" galvanized iron wire formed on a rim piece of ¼" galvanized iron wire. Size of mesh ½"
15"
PLAN
⅝" brass faucet
TOP
Rubber stopper
Flexible rubber tube
Pinch Cock
Constant-Level Bottle

To be made of sheet copper weighing 22 oz. per sq. ft., tinned inside. All seams to be lapped where possible. Hard solder only to be used.

Fig. 8

best with a straight-edge applied to the surface which was in contact with the plate.

65. In the present state of our knowledge it cannot be said that a cement which fails to pass the accelerated test will prove defective in the work; nor can a cement be conisdered entirely safe simply because it has passed these tests.

GEORGE S. WEBSTER, *Chairman.*
RICHARD L. HUMPHREY, *Secretary.*
W. B. W. HOWE,
F. H. LEWIS,
S. B. NEWBERRY,
ALFRED NOBLE,
CLIFFORD RICHARDSON,
L. C. SABIN,
GEORGE F. SWAIN.

METHODS FOR TESTING CEMENT.*

CONDENSED FOR USE IN SPECIFICATIONS.

1. **Sampling.**—Cement in barrels shall be sampled through a hole made in the head, or in one of the staves midway between the heads, by means of an auger or a sampling iron similar to that used by sugar inspectors; if in bags, the sample shall be taken from surface to center. Cement in bins shall be sampled in such a manner as to represent fairly the contents of the bin. The number of samples taken shall be as directed by the Engineer, who will determine whether the samples shall be tested separately or mixed.

The samples shall be passed through a sieve having 20 meshes per linear inch, in order to break up lumps and remove foreign material.

2. **Chemical Analysis.**—The methods to be followed, except for determining the loss on ignition should be those proposed by the Committee on Uniformtiy in the Analysis of Materials for the Portland Cement Industry, reported in the *Journal* of the Society for Chemical Industry, Vol. 21, p. 12, 1902, and published in *Engineering News*, Vol. 50, p. 60, 1903, and in *Engineering Record*, Vol. 48, p. 49, 1903, and in addition thereto the following:

(*a*) The insoluble residue may be determined as follows: To a 1-gram sample of the cement are added 30 cu. cm. of water and 10 cu. cm. of concentrated hydrochloric acid, and then warmed until effervescence ceases, and digested on a steam bath until dissolved. The residue is filtered, washed with hot water, and the filter paper and contents digested on the steam bath in a 5% solution of sodium carbonate. This residue is filtered, washed with hot water, then with hot hydrochloric acid, and finally with hot water, and then ignited at a red heat and weighed. The quantity so obtained is the insoluble residue.

(*b*) The loss on ignition shall be determined in the following manner: $\frac{1}{2}$ gram of cement is heated in a weighed platinum crucible, with cover, for 5 minutes with a Bunsen burner (starting with a low flame and gradually increasing to its full height) and then heated for 15 minutes with a blast lamp; the difference between the weight after cooling and the original weight is the loss on ignition. The temperature should not exceed 900° cent., or a low red heat; the ignition should preferably be made in a muffle.

---

*Accompanying Final Report of Special Committee on Uniform Tests of Cement, dated January 17th, 1912.

3. **Specific Gravity.**—The determination of specific gravity shall be made with a standardized Le Chatelier apparatus. This consists of a flask (*D*), Fig. 1, page 37, of about 120 cu. cm. capacity, the neck of which is about 20 cm. long; in the middle of this neck is a bulb (*C*), above and below which are two marks (*F*) and (*E*); the volume between these two marks is 20 cu. cm. The neck has a diameter of about 9 mm., and is graduated into tenths of cubic centimeters above the mark (*F*).

Benzine (62° Baumé naphtha) or kerosene free from water shall be used in making the determination. The flask is filled with either of these liquids to the lower mark (*E*) and 64 grams of cement, cooled to the temperature of the liquid, is slowly introduced through the funnel (*B*) (the stem of which should be long enough to extend into the flask to the top of the bulb (*C*)), taking care that the cement does not adhere to the sides of the flask, and that the funnel does not touch the liquid. After all the cement is introduced, the level of the liquid will rise to some division of the graduated neck; this reading, plus 20 cu. cm., is the volume displaced by 64 grams of the cement. The specific gravity is obtained from the formula,

$$\text{Specific gravity} = \frac{\text{Weight of cement, in grams,}}{\text{Displaced volume, in cubic centimeters.}}$$

The flask, during the operation, is kept immersed in water in a jar (*A*), in order to avoid variations in the temperature of the liquid in the flask, which should not exceed $\frac{1}{2}^\circ$ cent. The results of repeated tests should agree within 0.01.

The determination of specific gravity shall be made on the cement as received; if it should fall below 3.10, a second determination shall be made after igniting the sample at a low red heat. The ignition shall be carried out in the following manner:

The flask, during the operation, is kept immersed in water in a jar (*A*) in order to avoid variations in the temperature of the liquid in the flask, which should not exceed $\frac{1}{2}^\circ$ cent. The results of repeated tests should agree within 0.01. The determination of specific gravity should be made on the cement as received; if it should fall below 3.10, a second determination should be made after igniting the sample in a covered dish, preferably of platinum, at a low red heat not exceeding 900° cent. The sample should be heated for 5 minutes with a Bunsen burner (starting with a low flame and gradually increasing to its full height) and then heated for 15 minutes with a blast lamp; the ignition should preferably be made in a muffle.

4. **Fineness.**—The fineness shall be determined by weighing the residue retained on No. 100 and No. 200 sieves. The sieves, 8 inches in diameter, shall be of brass wire cloth conforming to the following requirements:

No. of sieve.	Diameter of wire.	Meshes per Linear Inch.	
		Warp.	Woof.
100	0.0042 to 0.0048 in.	95 to 101	93 to 103
200	0.0021 to 0.0023 "	192 to 203	190 to 205

The meshes in any smaller space, down to 0.25 inches, shall be proportional in number.

Fifty grams of cement, dried at a temperature of 100° cent. (212° Fahr.), shall be placed on the No. 200 sieve, which with pan and cover attached, is held in one hand in a slightly inclined position, and moved forward and backward about 200 times per minute, at the same time striking the side gently, on the up stroke, against the palm of the other hand. The operation is continued until not more than 0.05 gram will pass through in one minute. The residue is weighed, then placed on the No. 100 sieve, and the operation repeated. The work may be expedited by placing in the sieve a few large steel shot, which should be removed before the final one minute of sieving. The sieves should be thoroughly dry and clean.

5. **Normal Consistency.**—The amount of water, expressed in percentage by weight of the dry cement, required to produce a paste* of the plasticity desired, termed "normal consistency," shall be determined with the Vicat apparatus:

This consists of a frame (*A*), Fig. 2, page 40, bearing a movable rod (*B*), weighing 300 grams, one end (*C*) being 1 cm. in diameter for a distance of 6 cm., the other having a removable needle (*D*), 1 mm. in diameter, 6 cm. long. The rod is reversible, and can be held in any desired position by a screw (*E*), and has midway between the ends a mark (*F*) which moves under a scale (graduated to millimeters) attached to the frame (*A*). The paste is held in a conical, hard-rubber ring (*G*), 7 cm. in diameter at the base, 4 cm. high, resting on a glass plate (*H*) about 10 cm. square.

---

*The term "paste" is used in these specifications to designate a mixture of cement and water, and the word "mortar" to designate a mixture of cement, sand, and water.

In making the determination of normal consistency, the same quantity of cement as will be used subsequently for each batch in making the test pieces, but not less than 500 grams, together with a measured amount of water, is kneaded into a paste, as described in Section 9, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other maintained about 6 in. apart; the ball resting in the palm of one hand is pressed into the larger end of the rubber ring held in the other hand, completely filling the ring with paste; the excess at the larger end is then removed by a single movement of the palm of the hand; the ring is then placed on its larger end on a glass plate and the excess paste at the smaller end is sliced off at the top of the ring by a single oblique stroke of a trowel held at a slight angle with the top of the ring. During these operations care must be taken not to compress the paste. The paste confined in the ring, resting on the plate, is placed under the rod, the larger end of which is carefully brought in contact with the surface of the paste; the scale is then read, and the rod quickly released.

The paste is of normal consistency when the cylinder settles to a point 10 mm. below the original surface in one-half minute after being released. The apparatus must be free from all vibrations during the test.

Trial pastes are made with varying percentages of water until the normal consistency is attained.

Having determined the percentage of water required to produce a paste of normal consistency, the percentage required for a mortar containing, by weight, one part of cement to three parts of standard Ottawa sand, shall be obtained from the following table, the amount being a percentage of the combined weight of the cement and sand.

PERCENTAGE OF WATER FOR STANDARD MORTARS.

Neat.	One cement, three standard Ottawa sand.	Neat.	One cement, three standard Ottawa sand.	Neat.	One cement, three standard Ottowa sand.
15	8.0	23	9.3	31	10.7
16	8.2	24	9.5	32	10.8
17	8.3	25	9.7	33	11.0
18	8.5	26	9.8	34	11.2
19	8.7	27	10.0	35	11.3
20	8.8	28	10.2	36	11.5
21	9.0	29	10.3	37	11.7
22	9.2	30	10.5	38	11.8

6. **Time of Setting.**—The time of setting shall be determined with the Vicat apparatus in the following manner:

A paste of normal consistency is moulded in the hard-rubber ring, as described in Section 5, and placed under the rod (*B*), the smaller end of which is then carefully brought in contact with the surface of the paste, and the rod quickly released.

The cement is considered to have acquired its initial set when the needle ceases to pass a point 5 mm. above the glass plate; and the final set, when the needle does not sink visibly into the paste.

The test pieces must be kept in moist air during the test.

7. **Standard Sand.**—The sand shall be natural sand from Ottawa, Ill., screened to pass a No. 20 sieve, and retained on a No. 30 sieve.

The sieves shall be at least 8 in. in diameter, and the wire cloth shall be of brass wire and shall conform to the following requirements:

No. of sieve.	Diameter of wire.	MESHES PER LINEAR INCH.	
		Warp.	Woof.
20	0.016 to 0.017 in.	19.5 to 20.5	19 to 21
30	0.011 to 0.012 "	29.5 to 30.5	28.5 to 31.5

Sand which has passed the No. 20 sieve is standard when not more than 5 grams passes the No. 30 sieve in one minute of continuous sifting of a 500-gram sample.*

8. **Form of Test Pieces.**—For tensile tests, the form of test pieces shown in Fig. 3, page 43, shall be used.

For compressive tests, 2-in. cubes shall be used.

9. **Mixing and Moulding.**—The material shall be weighed, placed on a non-absorbent surface, thoroughly mixed dry if sand be used, and a crater formed in the center, into which the proper percentage of clean water shall be poured; the material on the outer edge shall be turned into the center by the aid of a trowel. As soon as the water has been absorbed, the operation of mixing shall be completed by vigorously kneading with the hands for one minute.

Immediately after mixing, the paste or mortar shall be placed in the mould (Figs. 4 and 5, page 44) with the hands, pressed in firmly with the fingers, and smoothed off with a trowel without ramming.

---

*This sand may now (1912) be obtained from the Ottawa Silica Co., at a cost of two cents per pound, f. o. b. cars, Ottawa, Ill.

The material shall be heaped above the mould, and, in smoothing off, the trowel shall be drawn over the mould in such a manner as to exert a moderate pressure on the material; the mould shall then be turned over and the operation of heaping and smoothing off repeated.

The temperature of the room and of the mixing water shall be maintained as nearly as practicable at 21° cent. (70° Fahr.).

10. **Storage of the Test Pieces.**—During the first 24 hours after moulding, the test pieces shall be stored in a moist closet. This consists of a box of soapstone or slate, or of wood lined with metal, the interior surface being covered with felt or broad wicking kept wet, the bottom of the box being kept covered with water. The interior of the box is provided with glass shelves on which to place the test pieces, the shelves being so arranged that they may be withdrawn readily.

Test pieces from any sample which vary more than 3% in weight from the average, after removal from the moist closet, shall not be considered in determining strength.

After 24 hours in the moist closet, the pieces to be tested after longer periods shall be immersed in water in storage tanks or pans made of non-corrodible material.

The air and water in the moist closet and the water in the storage tanks shall be maintained, as nearly as practicable, at 21° cent. (70° Fahr.).

11. **Tests of Tensile Strength.**—The tests may be made with any standard machine.

The clip is shown in Fig. 6, page 46. It must be made accurately, the pins and rollers turned, and the rollers bored slightly larger than the pins so as to turn easily. There should be a slight clearance at each end of the roller, and the pins should be kept properly lubricated and free from grit. The clips shall be used without cushioning at the points of contact.

The test pieces shall be broken as soon as they are removed from the water. The load shall be applied at the rate of 600 lbs. per minute.

Test pieces which do not break within ¼ in. of the center, or are otherwise manifestly faulty, shall be excluded in determining average results.

12. **Tests of Compressive Strength.**—The tests may be made with any machine provided with means for so applying the load that the line of pressure is along the axis of the test piece. A ball-bearing block for this purpose is shown in Fig. 7, page 48.

The test pieces as soon as they are removed from the water shall be placed in the testing machine, with a piece of heavy blotting paper on each of the crushing faces, which should be those that were in contact with the mould.

13. **Constancy of Volume.**—The tests of constancy of volume comprise "normal tests," which are made in air or water, maintained as nearly as practicable at 21° cent. (70° Fahr.), and the "accelerated test," which is made in steam. These tests shall be made in the following manner:

Pats about 3 in. in diameter, ½ in. thick at the center, and tapering to a thin edge, shall be made on clean glass plates (about 4 in. square) from cement paste of normal consistency, and stored in a moist closet for 24 hours.

Normal Tests.—After 24 hours in the moist closet, a pat is immersed in water and observed at intervals. A similar pat, after 24 hours in the moist closet, is exposed to the air for 28 days or more and observed at intervals. The air and water are maintained, as nearly as practicable, at 21° cent. (70° Fahr.).

Accelerated Test.—After 24 hours in the moist closet, a pat is placed in an atmosphere of steam, upon a wire screen 1 in. above boiling water, for 5 hours, the apparatus being such that the steam will escape freely and atmospheric pressure be maintained. The apparatus is shown in Fig. 8, page 49.

The cement passes these tests when the pats remain firm and hard, with no signs of cracking, distortion, or disintegration.

CHEMICAL ANALYSES.

Reprint of Report Authorized by the Committee.

NEW YORK SECTION SOCIETY FOR CHEMICAL INDUSTRY.

Method Suggested for the Analysis of Limestones, Raw Mixtures and Portland Cements by the Committee on Uniformity in Technical Analysis with the Advice of W. F. Hillebrand.

Solution.—One-half gram of the finely powdered substance is to be weighed out, and, if a limestone or unburned mixture, strongly ignited in a covered platinum crucible over a strong blast for 15 minutes, or longer if the blast is not powerful enough to effect complete conversion to a cement in this time. It is then transferred to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, moistened with enough water to prevent lumping, and 5 to 10 c.c. of strong HCl added and digested with the aid of gentle heat and agitation until solution is complete. Solution may be aided by light pressure with the flattened end of a glass rod.* The solution is then evaporated to dryness, as far as this may be possible on the bath.

Silica (SiO_2).—The residue without further heating is treated at first with 5 to 10 c.c. of strong HCl which is then diluted to half strength or less, or upon the residue may be poured at once a larger volume of acid of half strength. The dish is then covered and digestion allowed to go on for 10 minutes on the bath, after which the solution is filtered and the separated silica washed thoroughly with water. The filtrate is again evaporated to dryness, the residue without further heating taken up with acid and water and the small amount of silica it contains separated on another filter paper. The papers containing the residue are transferred wet to a weighed platinum crucible, dried, ignited, first over a Bunsen burner until the carbon of the filter is completely consumed, and finally over the blast for 15 minutes and checked by a further blasting for 10 minutes or to constant weight. The silica, if great accuracy is desired, is treated in the crucible with about 10 c.c. of HFl and four drops of H_2SO_4, and evaporated over a low flame to complete dryness. The small residue is finally blasted, for a minute or two, cooled and weighed. The difference between this weight and the weight previously obtained gives the amount of silica.*

---

*If anything remains undecomposed it should be separated, fused with a little Na_2CO_2, dissolved and added to the original solution. Of course a small amount of separated non-gelatinous silica is not to be mistaken for undecomposed matter.

Alumina and Iron (Al_2O_3 and Fe_2O_3).—The filtrate, about 250 c.c., from the second evaporation for SiO_2, is made alkaline with NH_4OH after adding HCl, if need be, to insure a total of 10 to 15 c.c. strong acid, and boiled to expel excess of NH_3, or until there is but a faint odor of it, and the precipitate iron and aluminum hydrates, after settling, are washed once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate is dissolved in hot dilute HCl, the solution passing into the beaker in which the precipitation was made. The aluminum and iron are then reprecipitated by NH_4OH, boiled and the second precipitate collected and washed on the same filter used in the first instance. The filter paper, with the precipitate, is then placed in a weighed platinum crucible, the paper burned off and the precipitate ignited and finally blasted 5 minutes, with care to prevent reduction, cooled and weighed as $Al_2O_3 + Fe_2O_3$.†

Iron (Fe_2O_3).—The combined iron and aluminum oxides are fused in a platinum crucible at a very low temperature with about 3 to 4 grams of $KHSO_4$, or, better, $NaHSO_4$, the melt taken up with so much dilute H_2SO_4 that there shall be no less than 5 grams absolute acid and enough water to effect solution on heating. The solution is then evaporated and eventually heated till acid fumes come off copiously. After cooling and redissolving in water the small amount of silica is filtered out, weighed and corrected by HFl and H_2SO_4.‡ The filtrate is reduced by zinc, or preferably by hydrogen sulphide, boiling out the excess of the latter afterwards while passing CO_2 through the flask, and titrated with permanganate.§ The strength of the permanganate solution should not be greater than 0.0040 gr. Fe_2O_3 per c.c.

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*For ordinary control in the plant laboratory this correction may, perhaps, be neglected: the double evaporation never.

† This precipitate contains TiO_2, P_2O_5, Mn_3O_4.

‡ This correction of Al_2O_3 Fe_2O_3 for silica should not be made when the HFl correction of the main silica has been omitted, unless that silica was obtained by only one evaporation and filtration. After two evaporations and filtrations 1 to 2 mg. of SiO are still to be found with the Al_2O_3 Fe_2O_3.

§ In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

Lime (**CaO**).—To the combined filtrate from the $Al_2O_3 + Fe_2O_3$ precipitate a few drops of NH_4OH are added, and the solution brought to boiling. To the boiling solution 20 c.c. of a saturated solution of ammonium oxalate are added, and the boiling continued until the precipitated CaC_2O_4 assumes a well-defined granular form. It is then allowed to stand for 20 minutes, or until the precipitate has settled, and then filtered and washed. The precipitate and filter are placed wet in a platinum crucible, and the paper burned off over a small flame of a Bunsen burner. It is then ignited, redissolved in HCl, and the solution made up to 100 c.c. with water. Ammonia is added in slight excess, and the liquid is boiled. If a small amount of Al_2O_3 separates this is filtered out, weighed, and the amount added to that found in the first determination, when greater accuracy is desired. The lime is then reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed,* weighed as oxide by ignition and blasting in a covered crucible to constant weight, or determined with dilute standard permanganate.†

Magnesia (**MgO**).—The combined filtrates from the calcium precipitates are acidified with HCl and concentrated on the steam bath to about 150 c.c., 10 c.c. of saturated solution of $Na(NH_4)HPO_4$ are added, and the solution boiled for several minutes. It is then removed from the flame and cooled by placing the beaker in ice water. After cooling, NH_4OH is added drop by drop with constant stirring until the crystalline ammonium-magnesium orthophosphate begins to form, and then in moderate excess, the stirring being continued for several minutes. It is then set aside for several hours in a cool atmosphere and filtered. The precipitate is redissolved in hot dilute HCl, the solution made up to about 100 c.c., 1 c.c. of a saturated solution of $Na(NH_4)HPO_4$ added, and ammonia drop by drop, with constant stirring until the precipitate is again formed as described and the ammonia is in moderate excess. It is then allowed to stand for about 2 hours, when it is filtered on a paper or a Gooch crucible, ignited, cooled and weighed as $Mg_2P_2O_7$.

Alkalies (**K_2O and Na_2O**).—For the determination of the alkalies, the well-known method of Prof. J. Lawrence Smith is to be followed, either with or without the addition of $CaCO_3$ with NH_4Cl.

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* The volume of wash-water should not be too large; *vide* Hillebrand.

† The accuracy of this method admits of criticism, but its convenience and rapidity demand its insertion.

Anhydrous Sulphuric Acid (SO_3).—One gram of the substance is dissolved in 15 c.c. of HCl, filtered and residue washed thoroughly.*

The solution is made up to 250 c.c. in a beaker and boiled. To the boiling solution 10 c.c. of a saturated solution of $BaCl_2$ is added slowly drop by drop from a pipette and the boiling continued until the precipitate is well formed, or digestion on the steam bath may be substituted for the boiling. It is then set aside over night, or for a few hours, filtered, ignited and weighed as $BaSO_4$.

Total Sulphur.—One gram of the material is weighed out in a large platinum crucible and fused with Na_2CO_3 and a little KNO_3 being careful to avoid contamination from sulphur in the gases from source of heat. This may be done by fitting the crucible in a hole in an asbestos board. The melt is treated in the crucible with boiling water and the liquid poured into a tall narrow beaker and more hot water added until the mass is disintegrated. The solution is then filtered. The filtrate contained in a No. 4 beaker is to be acidulated with HCl and made up to 250 c.c. with distilled water, boiled, the sulphur precipitated as $BaSO_4$ and allowed to stand over night or for a few hours.

Loss on Ignition.—Half a gram of cement is to be weighed out in a platinum crucible, placed in a hole in an asbestos board so that about three-fifths of the crucible projects below, and blasted 15 minutes, preferably with an inclined flame. The loss by weight, which is checked by a second blasting of 5 minutes, is the loss on ignition.

May, 1903: Recent investigations have shown that large errors in results are often due to the use of impure distilled water and reagents. The analyst should, therefore, test his distilled water by evaporation and his reagents by appropriate tests before proceeding with his work.

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* Evaporation to dryness is unnecessary, unless gelatinous silica should have separated and should never be performed on a bath heated by gas; *vide* Hillebrand.

693
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P83
no. 26

USE ALPHA CEMENT FOR HIGH EARLY STRENGTH CONCRETE

CONCRETE FOR PERMANENCE

ALPHA PORTLAND
CEMENT COMPANY
EASTON, PA. CHICAGO, ILL.

High Early Strength Concrete

Theoretical? Yes;
But Practical Also
by using
Alpha Portland Cement

Alpha Portland Cement Company
Easton, Pa. Chicago, Ill.
Boston New York Philadelphia Baltimore
Pittsburgh St. Louis Battle Creek, Mich.
Ironton, Ohio

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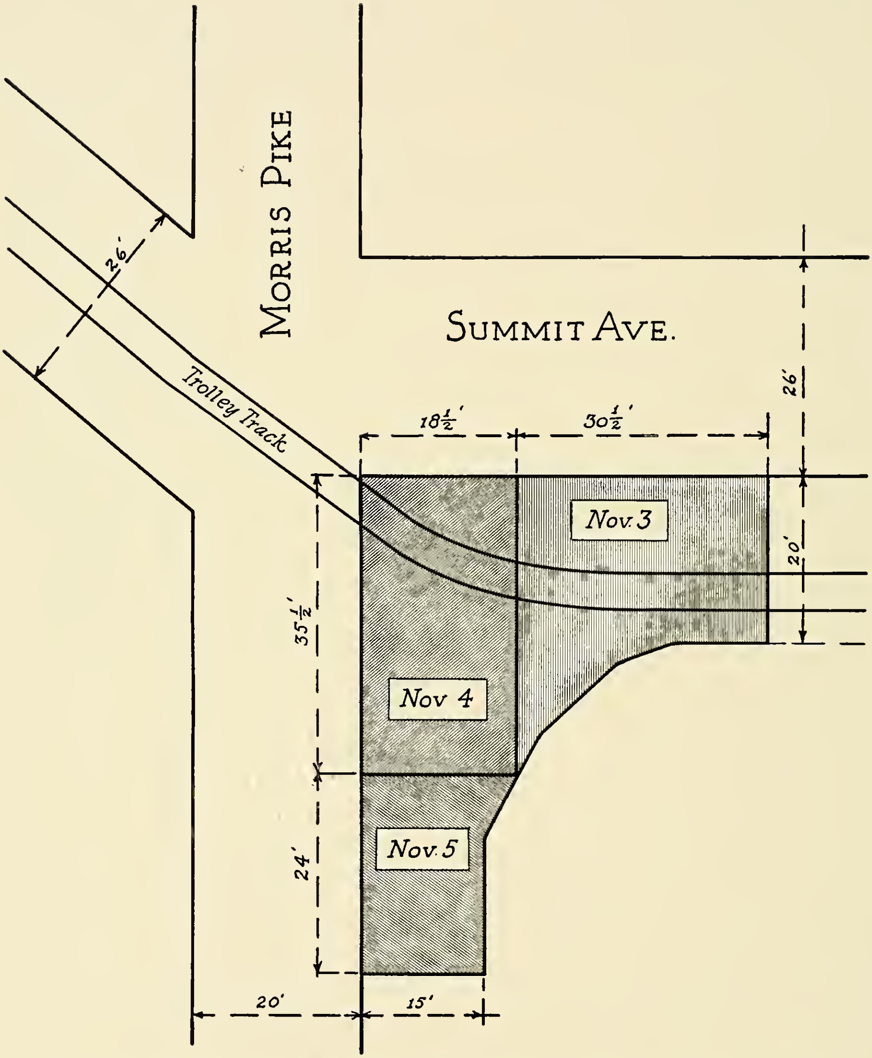


Sketch of the high early strength concrete placed Nov. 3, 4 and 5, 1926, at Phillipsburg, N. J.

High Early Strength Concrete

Theoretical? Yes; but Practical also by using Alpha Portland Cement

WE, of the Alpha Portland Cement Company, have heard a great deal about high early strength cement, super cement, high alumina cement, etc., all varying in greater or less degree from Portland cement manufactured under A. S. T. M. standard specifications. Thirty-six years' experience in the manufacture of Alpha Portland Cement has convinced us that cement manufactured to meet the A. S. T. M. specifications will generally more than meet the requirements of the average user. Where the user wishes a high early strength concrete, we are also convinced that our regular cement is best from the practical viewpoint.

The water cement ratio which was developed in the laboratory of the Portland Cement Association in Chicago provides a means whereby the user of cement may get a concrete of high early strength without being required to take the many precautions which are necessary when special cements are used. To test out our conviction theoretically, the Alpha Portland Cement Company made some experiments during 1926 on quick hardening or high early strength concrete.

Samples from our cement at Martins Creek, Pa., and at Catskill, N. Y., (regular stock in both instances) were taken to the Engineering Laboratory of Lafayette College. Under supervision of that laboratory a series of cylinders were made from these cements with various amounts of water and various mixes of cement, sand and stone. A mix of one part cement, one and a half parts sand and two and a half parts crushed stone or gravel with five and one-half gallons of water per sack of cement was used and compared with the same mix using 4.4 gallons of water per sack of cement. The compressive strength of the cylinders from these two cements were as follows:

MARTINS CREEK, PA., PLANT

Gallons of water per Sack of Cement	1 day	3 days	7 days	28 days
5.5	728	1976	2551	4658
4.4	1476	2898	4145	5775

CATSKILL, N. Y., PLANT

Gallons of water per Sack of Cement	1 day	3 days	7 days	28 days
5.5	570	1928	2905	4602
4.4	1059	2558	3996	5470

The dry mixture being shoveled into place

Another series of tests were made with a mix of one part cement, two and a half parts sand and four parts crushed stone or gravel with 7.7 gallons of water per sack of cement and compared with a series of the same mix using 6.1 gallons of water per sack of cement, with the following results:

MARTINS CREEK, PA., PLANT

Gallons of Water per Sack of Cement	1 day	3 days	7 days	28 days
7.7	421	836	1614	3008
6.1	654	1518	2142	3812

CATSKILL, N. Y., PLANT

7.7	182	978	1798	2575
6.1	617	1512	2515	3342

The tensile strengths of these cements made according to standard methods follow:

MARTINS CREEK, PA., PLANT

1 part cement, 3 parts Standard Ottawa Sand
Pounds per square inch, 3 days—266
7 days—301
28 days—396

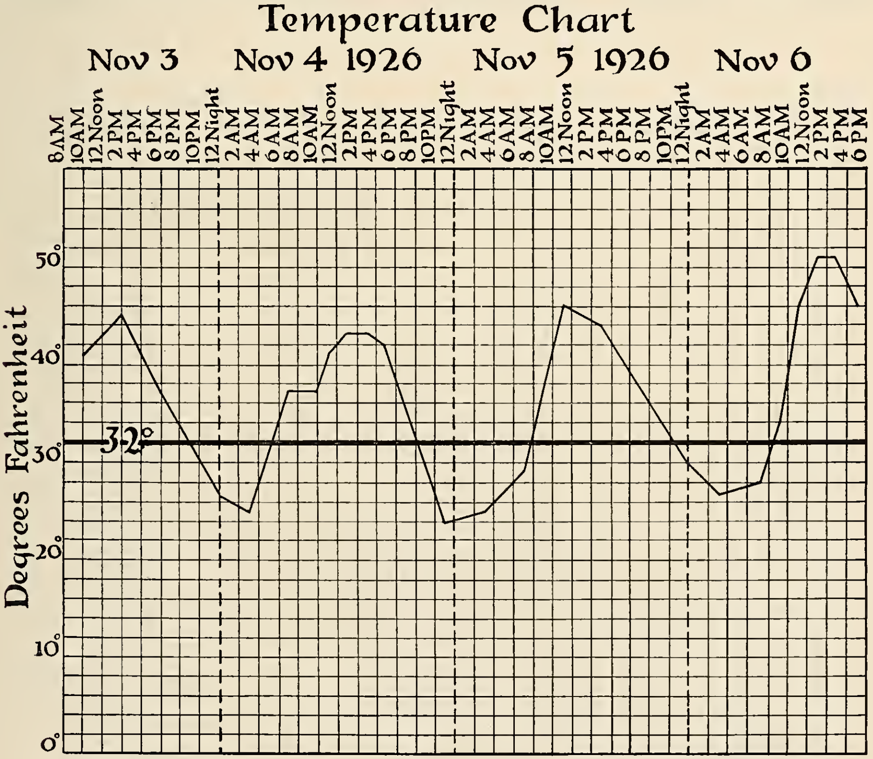
High Early Strength Concrete

CATSKILL, N. Y., PLANT

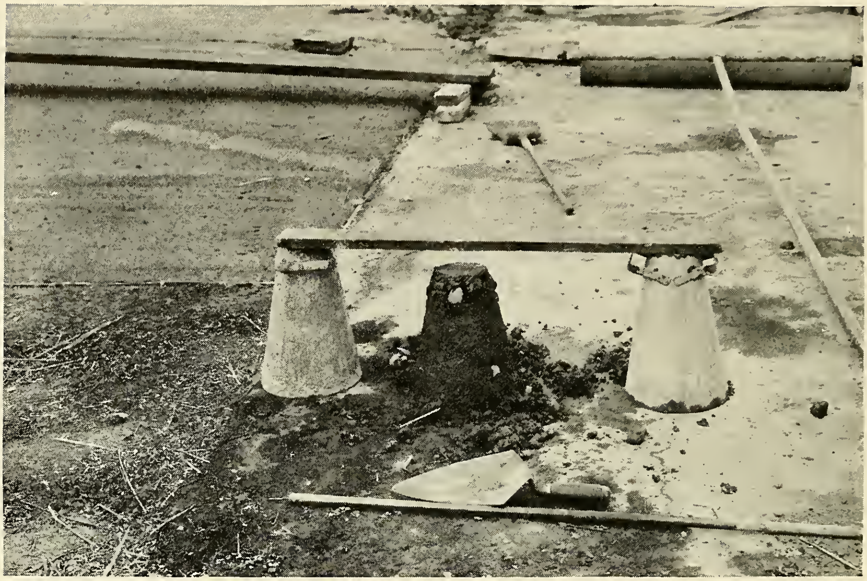
1 part cement, 3 parts Standard Ottawa Sand
Pounds per square inch, 3 days—258
7 days—339
28 days—441

These results indicate plainly the advantage of "dry mix" over "wet mix." Other mixes than those shown were also used and in every instance the lowering of the water content gave similar higher strength at early ages over the ordinary quantity of water. In developing these facts, over 1,000 concrete cylinders 8″ x 16″ were made and broken on the compression machine. These results satisfied us that standard Alpha Portland Cement without question would do all and more than most users of cement might require.

The next thing was to apply the principle practically and see whether the theoretical results would be found in actual practice. In the early fall of 1926, the City of Phillipsburg, N. J., planned to pave with concrete a small intersection at Meadow Avenue and Morris Pike. This Company procured permission from the Phillipsburg authorities



Range of temperature during progress of work. It will be observed that freezing weather occurred each night



A slump test on the job

The cylinders made from batches of the mixture. A canvas and straw covering used to protect the green concrete

Truck loaded with sand, total weight of 17,100 lbs. on road at end of 24-hour period

(Street Commissioner John Laughland and City Engineer Harry Meixell) to have this intersection put down with a mix planned for high early strength concrete and with the understanding that it should be opened for traffic not more than three days after the concrete was poured, and sooner if we felt such action was warranted.

It was expected that the concrete would be laid in the early part of October before the weather should turn cold. Unfortunately, one thing after another came up to hinder the progress of the work and it was not until the first week in November that the contractor (Korp & Korp of Phillipsburg) was ready to pour the concrete. There was some question whether it was wise to make the practical test under such circumstances, because most Highway Engineers are unwilling to have a concrete pavement laid under such conditions. However, the management of the Alpha Company felt that if it was right in its belief as to the value of this method of making concrete, it would be just that much better should the concrete be laid under abnormal and disadvantageous conditions, and so went ahead with the construction. The contractor was not equipped to lay the whole intersection in one day and, therefore, the work was carried on for three days before the job was completed. At the end of forty-eight hours the concrete appeared to be sufficiently hard from superficial tests to warrant traffic. It was necessary, however, to finish the balance of the intersection before the road could be opened,

Ready for the truck test over sharp edge of the green concrete at end of 48 hours. The weather was cold and none too favorable for the test but the new slab bore the truck weight of 17,100 lbs. without the slightest evidence of weakness

but for our own satisfaction a truck weighing, with load, 17,100 pounds, was run upon the twenty-four hour concrete and pulled up over the edge of the forty-eight hour concrete, without marring the edge of the concrete or disturbing in the slightest the broom marks of the finisher. Twenty-four hours after the final section was laid, the road was open to traffic and has been in service ever since. The broom marks on the concrete are still as plain as when the concrete was first used.

The road happens to be one that is very heavily travelled (4,000 vehicles daily, New Jersey census) so that this particular concrete has been used almost continuously. About twenty days after the concrete was laid, the Highway Department of the State of New Jersey took two cores. These two cores were crushed twenty-eight days after the concrete was placed and gave strengths in compression of 4187 pounds per square inch and 4611 pounds per square inch respectively.

Mr. H. Eltinge Breed, a prominent Highway Engineer, made a careful examination of this pavement the latter part of November and writes as follows:

"On November 27, 1926, a close observation of this section revealed its integrity with clear, sharp cut broom marks in the surface, despite the fact that this intersection is in the city on a trunkline leading north-

Walter P. Lewis, Engineer of Tests, measuring depression in loose earth made by truck weighing 17,100 lbs., which was pulled up over the edge of the forty-eight hour concrete without marring the edge

easterly to Belvidere and Washington, and also serving the northeastern suburbs of the city which have considerable mixed traffic."

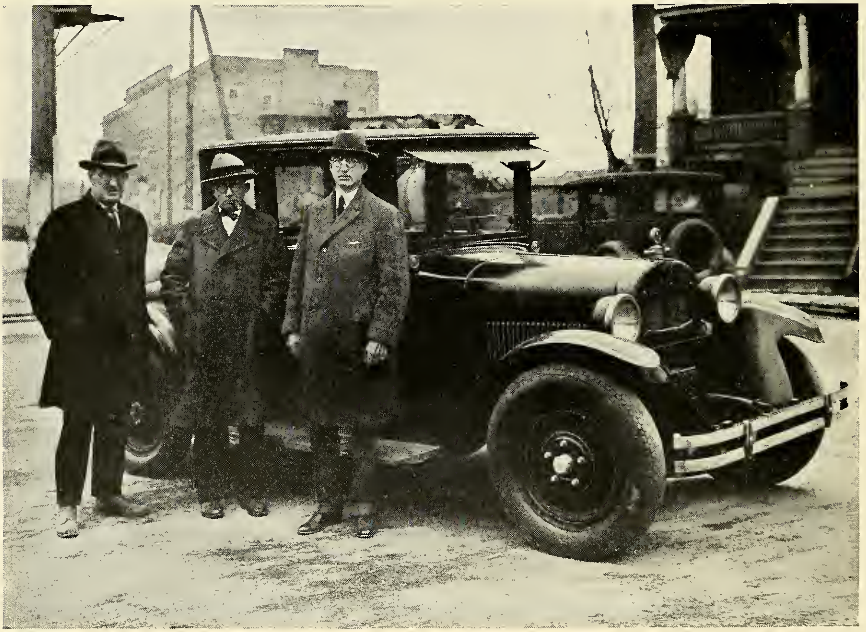
We are firmly convinced that where necessary it is possible with standard Alpha Portland Cement to pour concrete and use it in from twenty-four to seventy-two hours. Where it is desired to use concrete twenty-four or forty-eight hours after it is placed a somewhat richer mixture in cement than is ordinarily used (8 to 15%) is indicated. The mixing time should be increased. In this particular case each batch was in the mixer five minutes. We are satisfied that practically the same results may be obtained by mixing for not more than three minutes. Care should be taken in cold weather to heat the aggregate and water and to see that the aggregate is well graded. The cement used was the regular standard Alpha Portland Cement which we manufacture and sell to the trade. There was nothing special in its method of manufacture or in its composition.

Using this method there is no reason why cement concrete should not be the preferred material for city streets. Even with the slight additional cost for cement and time of mixing this pavement will be much cheaper than competitive material.

It is valuable furthermore for any other construction which is wanted quickly after the concrete is poured. In repair work about the mills of the Alpha Portland Cement Company it is a rare thing for concrete not to be in use forty-eight hours after it is poured and not infrequently twenty-four hours is the limit.

To those interested we will be glad to send a pamphlet giving the engineering and technical details of the construction described.

Easton, Pa.
March, 1927



Cold enough for overcoats and radiator covers! The gentlemen shown standing on the finished job are (left to right) John Laughland, Street Commissioner of Phillipsburg, N. J., Frank Korp, of Korp & Korp, Contractors, Phillipsburg, N. J., Louis Anderson, Jr., Chemical Engineer, Alpha Portland Cement Company, Easton, Pa.

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